NERVOUS AND MENTAL DISEASE MONOGRAPH SERIES NO. 10.

Handbook
of
Mental Examination Methods

By

Shepherd Ivory Franz, Ph.D.

Scientific Director and Psychologist, Government Hospital for the Insane
Professor of Physiology, George Washington University.

With 33 Figures and Diagrams

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To

EDWARD COWLES

who has placed the sciences of psychiatry and psychology in his debt by his insistence on the functional study of the psychoses and by the foundation of the first psychological laboratory for the investigation of the insane in these United States.

"Ohne den Wert instrumenteller Einrichtungen, speziell den eines psychophysischen Laboratoriums zu unterschätzen, meine ich, dass der klinische Fortschritt wesentlich von der allgemeinen Einführung solcher einfacher Methoden, deren Anwendung in einem bescheiden ausgestatteten klinischen Untersuchungszimmer möglich ist, abhängen wird." Sommer: Lehrbuch der psychopathologischen Untersuchungsmethoden. 1899. P. 391.

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PREFACE

The present work is the direct outcome of a series of lectures and demonstrations of neurological and mental examination methods which the author gave in a course to the internes of the Government Hospital for the Insane, first in 1910 and again in 1911. It is also partly due to repeated suggestions that the scheme of examination first published in White's "Outlines of Psychiatry" (Chapter 7) be elaborated. The book is intended to place in the hands of psychiatrists, neurologists and students methods of examination which have been successfully used in psychological practice, to the end that the mental examination of patients may be conducted in a more systematic and scientific manner.

It matters little what the mental examination may be called. It may be termed "psychological," or "mental," or, as many prefer, it may be called "clinical," especially if the examination does not include the testing of the subject by methods which are thought to be too complex, to require special apparatus, and consequently to be performed only within a special laboratory. At the present time it will be recognized that the term "clinical" in relation to the methods of internal medicine has been greatly broadened to include methods which ten years ago were called "laboratory" and in another ten years a similar change in the connotation of the term may be expected to take place in regard to the designation of some of the present methods of mental analysis.

An endeavor has been made to select methods which not only serve to show certain phases of mental processes, but which at the same time are easy to perform and are sufficiently accurate for certain kinds of research as well as for routine clinical purposes. All the methods which are described have been successfully used by the author from time to time, but it must not be assumed that each and every test may or must be applied to each

and every patient who is to be examined. Alternative methods are often given because the author has found that one method can not be used with advantage with all kinds of patients.

To one who is even superficially acquainted with psychological literature it will be apparent that many valuable methods have not been included. There were many reasons for these omissions. Certain psychological methods have been found to be too complex to be used with a number of patients, and for clinical purposes others require too great an amount of time because of the elaborate apparatus and adjustments. In certain cases, especially for research purposes, it may appear advisable to follow up mental states with a more careful analysis than can be made with the methods suggested here. For this reason there are added at the end of each chapter references to works dealing with the topics under consideration and in these works there will be found additional methods as well as information and criticism. With few exceptions these references are to books and articles in the English language. Additional references to German and French works will be found in the bibliographies attached to many of the articles and a fairly complete bibliography of works dealing with psychological matters is given in the yearly numbers of the Psychological Index.

This manual is not intended to be a text-book of psychology, nor is it intended in any way to take the place of psychological treatises. Only sufficient psychological discussion for orientation purposes is given here and extended discussion of psychological matters must be obtained from other psychological books and articles. The references at the end of Chapter I will give some indication of those which are most available and most beneficial. To psychiatrists a word of caution may be given regarding these text books. The psychological value of any particular work must not be judged by the information which the writer has of the insane and of other abnormal classes. As a rule, psychologists have had neither the opportunity nor the inclination to observe or to investigate the abnormal and their discussions of these topics are often unsatisfactory on account of second-hand information.

In Chapter XI the scheme of examination, mainly by the con-

versational method, which was put into operation in this hospital in 1907 is included, with the exception of the parts dealing with special methods. The latter will be found discussed in the separate chapters. In accordance with the demands of experience, the scheme of examination has been altered in slight particulars.

SHEPHERD IVORY FRANZ.

GOVERNMENT HOSPITAL FOR THE INSANE,
August, 1911.

HANDBOOK OF MENTAL EXAMINATIONS

CHAPTER I

INTRODUCTION

In no branch of medicine during the past three decades have advances been more rapid and the viewpoint more changed than in psychiatry. The modern conception of insanity had its origin about a hundred years ago, when Pinel and others, not only metaphorically but also actually, broke the chains that bound the insane. From that time the insane were treated more like human beings. This early psychiatric revolution accomplished much, but it led to a farther development in which we now have more interest. This is the recognition of the fact that the insane are individuals with diseases, individuals who are in need of treatment and medical care. The work of Pinel changed the character of the places in which the insane were kept from prisons to asylums; later workers have changed many of the asylums into hospitals, and to the custodial function have added physical, mental and social treatment.

In its methods, psychiatry differs much from general medicine and surgery. Both surgery and medicine deal with bodily abnormalities and disordered functions which are often determinable in certain physical and chemical constants, and, by the application of physical and chemical means, the surgeon or physician attempts to produce more normal conditions of function.

In psychiatry, mental states are the chief concern, and these must be observed, measured and dealt with in ways different from those applicable to a broken bone or a diseased heart. This does not mean that the psychiatrist needs no information regarding surgery and internal medicine. On the contrary, it is well known that the body and mind are in the closest connection, that some mental disturbances are the direct outcome of primary diseases of organs other than the brain, and that hallucinations,

delusions and emotional disorders may at times vanish concomitantly with the physical diseases.

Because the facts with which psychiatry deals are of a mental order it is the fashion in some places to assume that these can not be well understood and that the science of psychiatry can not be exact. In other quarters it is assumed that because each of us has a mind it is easy to observe the mental condition of others and to draw proper conclusions from these observations. For one who has any knowledge of the world in general and of science in particular it takes but little acumen to see the fallacy of both of these views.

It is true that in our dealings with men each of us is successful in proportion to our ability to judge correctly of the mental states of others. We need not have a university psychological training for this purpose, for all acquire from experience a certain fund of psychological knowledge, although it is not usually thus designated. It is, however, a habit, fostered by laziness, to say that common sense alone is necessary to determine the mental condition of another. By common sense we mean an ability, instinctive in character and not produced by specific education, to form judgments regarding the facts in the environment and to act in accordance with the judgments. All possess some of this ability of common sense; but some possess it to a greater and some to a lesser degree. It is true that in all scientific work we start on the basis of common sense. But, science is more than common sense; it is common sense systematized. It is the systematic observation, the orderly arrangements of the observations, and deductions from these observations.

It is just as absurd to say that because each of us has a mind we are able to draw deductions of scientific psychological value as it is to say that because each of us has a body, composed of cells, we are able to draw deductions of scientific histological value. Anatomical methods have been devised and numerous facts have been gathered and correlated, which it is necessary for one engaged in anatomical and histological work to take into account. So it is with mental facts and methods. If it is our business to deal with mind, we must, for the furtherance of the value of our work and for the proper examination and estimation of our

material, know what has been accomplished, what facts have been gathered and what methods have been employed.

If the physician believes that no special training or knowledge other than that obtained in a medical school course is necessary in order to deal with mental disease, he thereby places himself upon the same level with the laity as far as mental phenomena are concerned, because he has had no psychological training in the medical school. He who believes this should make no complaint and utter no protest that charlatans of all kinds exploit the mental weaknesses and mental peculiarities of a large part of the community, for these irregular practitioners have the same equipment as the physician to enable them to deal with mental states. Much of the success that Christian Science and other similar cults have had is due to their appreciation of mental mechanics and to the lack of appreciation of some physicians of the fact that there is a science of the mind. The recent requirement that each medical student shall have some instruction in psychiatry is a gratifying evidence of the appreciation of the importance of mental science in medicine, and recent developments indicate that psychology will assume an even greater prominence in the medical curriculum. When this advance shall have been made, all physicians will be in a better position to appreciate the mental aspect of the science of medicine.

The terms psychology, psychiatry, psychopathology, neurology and their derivatives appear to be poorly understood by many. It is not uncommon to find that the neurologist uses the terms psychological and neurological interchangeably; and others use the terms psychopathology, psychiatry and psychology as if they were synonymous. The four sciences have, it is true, very close relations with one another, but these relations are not so close that the terms may be used interchangeably and it would be advantageous to all of these sciences if the terms were not so often misused.

The subject matter of psychology is difficult to define. In brief, psychology is said to be "the science of mind," or the "science of consciousness," or the "science which treats of actual psychical processes, their objects as such, and the conditions of their occurrences" (Baldwin). According to these definitions the field of psychology is very broad and within its limits there

is included much that the psychiatrist and neurologist believe to be their special fields. Although the term is broad, the professional psychologists, by their activities, have limited the use of the term to the consideration of the phenomena of the normal mind, and to those mental processes which are conscious. Psychology is, however, not a strictly anatomical or dissecting science. It is also concerned with the conditions of the occurrence of mental states, and in this way takes into account the "how" as well as the "what."

The term psychopathology is used to indicate that mental science which includes the observation and explanation of all abnormal mental processes. These abnormal mental processes and states may be found among the so-called abnormal people or classes such as the insane and imbeciles, among the defectives such as the blind or deaf, or they may be found in so-called normal people under certain abnormal conditions. It is not necessary that the abnormality be of such a degree or that the process continue for so long a time that the individual requires institution care and treatment, but it is sufficient that the states which are observed be unlike those of normal people under similar conditions. Jastrow draws the distinction that psychopathology as compared with abnormal pathology "emphasizes the pathological while the latter term emphasizes the psychological point of view." Psychopathology is concerned with abnormalities of a mental nature regardless of the associations or combinations of the abnormalities into special disease forms. Its field, therefore, is quite definite, although it borders upon both psychology and psychiatry.

By derivation and usage the term psychiatry is used to designate that branch of medicine which deals with "mental healing." This term is quite distinct from psychology and from psychopathology in that it connotes a science dealing with combinations of symptoms which scientifically and popularly are known as diseases. Under this term there is included the study of all forms of mental alienation. This study includes consideration of the causation, the course, the outcome, and the treatment for the different forms of mental disease. The psychiatrist deals then with mental disease, his prime object is to differentiate one mental disease from another, to consider how these may be

diagnosed, to work out methods of therapeutics and to apply these methods to the individuals with whom he comes in contact.

Neurology is a term with a double meaning. In its more general sense it is the science dealing with the structure and functions of the nervous system and thus includes all topics which in any way bear upon the nervous structures. In a more restricted sense as a medical science, the term is used for that discipline which deals with diseases of the nervous system, including causation or origin, course, and treatment. In both senses this term may be considered very broadly to include the study of all phenomena in connection with the nervous system. Since the mind is associated with the activity of parts of the nervous system, all mental sciences are considered by some to be a part or parts of the general subject of neurology. It can not be said, however, that this way of broadly considering the field is advantageous to neurology and the more careful writers limit the term to the study of the normal and abnormal structures and functions of the nervous system.[1] Those states and processes which are mental are excluded because we have little definite knowledge regarding the relations of mental processes to the activities or to the structures of the nervous elements.

It will be seen that these four sciences which are independent to a great extent are, nevertheless, overlapping and it is impossible to separate by sharp lines one of these disciplines from the other three. Psychology borders upon psychiatry and neurology, and is closely associated with psychopathology. Psychopathology is very closely connected with psychiatry, less so with neurology. Neurology and psychiatry are also very closely associated. Dealing, as it does, with the normal mental processes, psychology is a discipline which needs to be taken into account by both psychopathologists and psychiatrists. Both of these specialists must know what mental processes are normal and what criteria the normal processes have that they may be able to judge rightly regarding the abnormal. The psychopathologist deals primarily with the abnormal mental processes and, except in an indirect way, is not concerned with the occurrences of these abnormal

[1] Some neurologists who appear to consider psychology a part of neurology inconsistently refuse to believe that the psychologist, who contributes to an understanding of the mind, is thereby a neurologist.

states in combinations which we call disease. The psychiatrist, on the other hand, is interested in the combinations of abnormal mental states which unite to make diseases. The interest of the psychiatrist is, therefore, in combinations of abnormal mental states and in the association of these into what are known as disease forms. The psychopathologist is interested in the abnormal states as such. The fields, therefore, of the psychiatrist and of the psychopathologist are partly the same in that they are the same phenomena, but they are distinct from each other because of the manner of considering the phenomena. The psychopathologist may deal with the genesis of an abnormal mental state, but the psychiatrist (as a psychiatrist) deals with the origin of a disease. The psychopathologist may deal with the relations of certain abnormal mental states to each other, the psychiatrist deals with the combinations of mental abnormalities into disease forms. The distinction may be made that, as medical disciplines, neurology and psychiatry are applied sciences, and that psychology and psychopathology are pure sciences. The psychologist and the psychopathologist are not concerned with treatment except in an indirect manner. The neurologist and the psychiatrist have treatment as one of their main concerns.

Mental states whether normal or abnormal are always complex; they are the results not only of present stimuli but also of the remnants, or of the effects, of all past experiences. In adults there are no mental states which are pure or isolated from all others. Each mental state or process is a part of all that has preceded it and, except in a purely logical manner, it is impossible to isolate or to differentiate one mental process from another one. All are interdependent and act together just as all parts of a machine or of the human body act together and interdependently. We may, for convenience, divide the parts of a machine into the wheels, the boiler, etc., and the parts of the human body into the nervous system, muscles, glands, bones, etc. We may, also, speak in a functional way of these different parts. We may consider the functions of the suprarenal glands or of the piston rod, but these parts do not work independently of other parts. The piston rod works with the wheels and its function depends upon the state of the steam in the boiler and upon the condition of certain valves. The suprarenal glands do not work independ-

ently of the thyroid and of other parts of the body. They work in conjunction with these other artificial anatomical elements. In the case of the suprarenals and of the piston rod, the interdependent activities produce the functional or physiological harmony.

In a similar manner we speak of the parts or elements of the mind. We may talk of memory by itself; we speak of sensation, apperception and various other processes, but these are not independent functions. Memory, for example, depends upon attention, upon apprehension, upon perception and upon a number of other factors. It can not be separated and isolated from these except in an artificial way nor can these other processes be separated from memory. It is for this reason that the consideration of separate elements in psychology and especially the anatomical divisions of the mind is not only difficult but also at times impossible. From the contents of the succeeding chapters it will be evident that the elements which are discussed depend upon each other to such an extent that conclusions regarding any one particular function can not be drawn without a knowledge of other mental states or processes upon which the one in question depends.

Before any mental examination or analysis is attempted the ability of the subject to understand questions must be first determined. If the subject does not understand what is required of him in the way of a voluntary reaction in particular tests, these tests can not be performed. Some information of mental conditions or states may be obtained without this cooperation or understanding on the part of the subject, but these states and processes are few and perhaps of least interest. It is necessary, therefore, that the tests be adapted to the individual and that the estimation of abnormality be based not upon the ability to perform certain definitely required reactions, but upon the actual reactions of the individual.

One of the most essential requirements for the conduct of a mental examination is the cooperation of the subject. In psychological laboratories in which normal mental processes are being investigated cooperation is obtained because of the scientific interest of the subject who is being tested. With the abnormal cooperation must not be assumed, but must be determined

and obtained in other ways. An appeal to his welfare, a brief discussion of his own case and the reason for his commitment to a hospital, or the statement that the experimenter needs the information for treatment, or other statements suitable to the individual may often be legitimately used for this purpose.

Introspection has rightly been called the primary method in psychology. It is an analysis by the subject of what is going on or has gone on in his mind. All subjects are not capable of reliable introspection but all subjects can and will introspect to a certain extent if carefully instructed and questioned. It must be admitted, that the introspection of abnormal individuals is not always to be relied upon, but on the other hand, neither are the introspections of all normal people to be relied upon. At times the abnormal are much more introspective than the normal of the same amount of education and of the same grade of intelligence. At times it appears that something has happened which causes those with psychoses to become abnormally introspective and to consider in great detail how certain of their mental processes have been produced. The accounts of these introspections are often of great value for an understanding of the genesis of certain derangements.

The experimental method which has been introduced into psychology during the past fifty years is a check upon introspection. With many of the abnormal it is the only method which can be used for obtaining definite data regarding certain processes. In this, as in introspective psychology, the cooperation of the subject is absolutely essential. Although the absence of cooperation is at times disconcerting to the psychologist or psychopathologist, at times it is also of as great diagnostic value for the psychiatrist as the performance of a test with cooperation. Negativism, for example, is a species of lack of cooperation and this even in slight degree is of some diagnostic value.

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CHAPTER II

SENSATION

Under the term sensation there are commonly grouped various mental experiences, widely differing in character, but we must be careful to differentiate what are properly known as sensations from the mental states which are based upon sensations and which are deductions from the sensory experiences. It is very common to hear both kinds of mental processes spoken of as sensations, but the latter more complex processes are correctly called perceptions. To make this matter plain, we may say that when we look at a plateful of food, our sensations are of colors, of extension and of intensity of light, but when these primary elements are combined mentally we have perceptions of a round plate, of a red apple, of a green pear, etc. In the examination of an individual it is often impossible to differentiate the elements which are abnormal sensorially and perceptually, although we should try to do this if we are to understand the perceptual disorders, which are very common and which are to be found in normal as well as in abnormal conditions.

From numerous experiments and analyses made during the past twenty years it is now recognized that man has not only five but twelve or more different kinds of sensation. The older fivefold division of sensation into vision, hearing, smell, taste, and organic sensation is no longer acceptable. The last mentioned, the organic kind of sensation, because of careful experiments and analyses, is now known to be made up of many sensations, some of which, especially those in the skin, have a common gross anatomical sense organ. We may say that the most important of the common sensations are as follows: static sense or sense of equilibrium, touch, the temperature sensations of heat and cold, pain, pressure, and the motor sensations from the muscles, from the joints and from the bones. It will be seen, therefore, that counting only those which have just been mentioned with these recognized many years ago we have twelve different kinds of sensations. To these we may add the feelings (or sensations)

of hunger, thirst, sex, tickle, dizziness, equilibrium, etc. This does not exhaust the total as recognized by many authors. These, however, are the kinds of sensations in which changes are very common and which are of most interest in pathological conditions.

Any one of these forms of sensation may be entirely lacking, and any sense organ may be so affected that the sensations obtained upon stimulation of it may be greatly exaggerated, or may become less intensive than under normal conditions. On the other hand, structural or functional alterations in the sense organ or in the central nervous apparatus may produce a condition in which the extensity of the sensation is altered. This is best recognized for the sensations mediated through the skin (hemianesthesia, monoanesthesia, etc.) and also for the light sensations (quadrantal hemiopia, contraction of field, etc.). Although we know little of the pathological changes in the time appearance and duration of sensations, this time element may be very important in the genesis of certain abnormal perceptions.

We shall first consider the time element in sensation. When a stimulus is given to any sense organ the sensation is not obtained immediately at the time of the stimulation. It requires an appreciable amount of time for the stimulus to act so that the stimulus may be sensed, and at the same time it takes an appreciable amount of time for the nervous mechanism to work before we become aware that a stimulus has been given. That it may be perceived, a color must work upon the retina of a subject experienced in these tests for about .005 second. When the stimuli are more complex the time is increased. After the stimulus has ceased the sensory process continues, giving rise to the after sensations, which are most prominent in the field of vision. If a bright light, like the sun or an arc lamp, be looked at, and then the eyes be closed, a persistent image of the stimulus remains. This is called the after-image.[1]

Similar phenomena are found in the field of the touch or pressure sensations. If a rubber band be stretched on the head and then removed, an after-image of the sensation is obtained. Although, as has been said, the time relations of the stimulus and sensation have received practically no attention in pathological

[1] S. I. FRANZ: After-images. Psychol. Rev. Monog. Suppl. no. 12. 1899. See pp. 18–19.

conditions, they are probably of considerable importance, but these relations need investigation. If the irritability of a tissue be increased the after-effect may be very prominent and may give rise to an image which, by the patient and by the examiner, may be considered hallucinatory. That the after-images (especially those of sight) may continue for long periods is well known, and if they do not entirely prevent the conscious appreciation of a following stimulus they may alter the sensory character of the latter.

Alterations in the extensity of sensations have been long recognized, and have been well studied in cases which are grouped under the general heading of anesthesias. The anesthesias due to organic disease are distributed in accordance with well known laws, and these sensation defects may be found in an organ for one kind of sensation and not another which is apparently closely allied to the one that is lost. For some of the sensations mediated through the peripheral nerves this has been well shown by the recent work of Head and his collaborators, and has also been shown for injuries and diseases of the spinal cord by many authors. One of the best known forms of areal dissociation from lesions of the cord is that found in syringomyelia. In this disease there are found certain normal sensations and certain abnormal ones. The distribution varies in different cases and according to the part of the cord which is involved by the disease. In the visual sphere the best known of the areal disturbances are those of hemianopsia and of contraction of the visual fields. For the sense of taste we find similar conditions, parts of the tongue giving no sensory response when stimulated, but extensity alterations in smell and hearing are not commonly recognized, unless we consider unilateral anosmia and deafness to be of this character. In the latter case, however, it is not usual, and perhaps it may not be justifiable, to speak of a loss of extent of sensation, for the remaining normal ear is capable of hearing sounds from all directions.

The term anesthesia has also been used to include the total loss of sensation in any sense field as well as a restriction of the field. The anesthesias are as varied as the number of sensations, and sometimes the anesthesias which are found are more varied than the sensation with which we deal. For example, we speak

of visual sensations, but we may have partial or complete anesthesia for color (commonly called color blindness), or for all kinds of light. We may also have an ageusia for definite kinds of taste, such as sweet, as well as a complete ageusia. In the field of the skin sensations this has been well shown by Head. It has been shown that almost any one of the different forms of sensation usually mediated through the skin may be lacking and the others intact. It is necessary, therefore, in considering any special case in which it seems advisable to test sensation, to go over all the different forms of sensation, testing each separately in order that there be a certainty that each form of sensation be intact.

Other alterations in the quantity of the sensations are known as (1) hypoesthesia, (*a*) when there is a decrease in the intensity of the sensation, or (*b*) when it is necessary to use a greater stimulus to produce a sensation, and (2) hyperesthesia, (*a*) when there is produced by a stimulus a sensation of a greater intensity than normal, or (*b*) when the areal distribution of the stimulus appears to be greater than what it actually is, or (*c*) when a less intensive stimulus produces a sensation. All these different forms of sensory alterations are to be distinguished clinically and all are, or should be, called by their appropriate names or carefully described.

Vision

The tests for myopia, hypermetropia, astigmatism, and heterophoria are so well known by physicians that they need no repetition here. The examination of the fundus of the eye is also an important procedure, because the condition of the retina determines visual ability and the character of the sensations, but the technique of this is also so well known by the physician that it requires no special description.

(*a*) *Visual Acuity.*—A simple test for visual acuity is readily made by the use of the method for determining the ability to discriminate two separate stimuli. Two separate white slips of paper, each 3 mm. long and 1 mm. wide, are glued on black cardboard 1 mm. apart (see Fig. 1). The card is pinned on the wall of the room in good illumination, and the patient is placed at a distance of 3 or 4 meters from it. He is instructed to describe what he sees. If at this distance he can see the two lines with

each eye, vision is normal. If the lines appear fused, have him move slowly toward the card and note the distance at which the apparent singleness of the lines gives way to the appearance of duality. The following are results of tests on subjects with

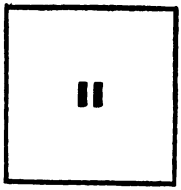

FIG. 1. Illustrating simple apparatus for testing acuity of vision. In the original the relations of light and shade are reversed.

approximately normal vision: 1 at 3.5 meters; 4 at 3 meters; 1 at 2.75 meters; 4 at 2.5 meters.

(*b*) *Field of Vision.*—The simplest method for determining the extent of the visual field is to place the patient in a chair facing and at a distance of about 30 cm. from you. Bring your hands on a level with the patient's eyes and about 50 cm. apart (*i. e.*, each hand about 20 cm. from the side of the patient's head). Instruct the patient to keep the eyes fixed on the end of your nose, and note that he does so. Wiggle the fingers and ask the patient to tell when he notices the movement. If the hands be moved forward the approximate extent of the visual field may be readily determined. Another simple method is to use a wire, to the end of which is attached a piece of white or colored paper. Hold the wire so that the paper is beyond the visual field, and while the patient's eyes are focused on your nose, bring the paper inwards until he notes that it is seen. Careful testing in this way with colored papers is a sufficiently accurate method for most clinical purposes, but it gives only qualitative results and requires more time than by the method which is next discussed.

A simple perimeter may be made like that illustrated in the accompanying diagram (Fig. 2).

A is 35 cm. long, *B* is 33.5 cm. long. Uprights of black cardboard, having .5 cm. white squares, are glued at right angles to the ends of *A* and *B* respectively, and the strips *A* and *B* are pinned together at *C* in such a way that *G* is about 2 to 3 mm. nearer *C* than is *F*. On *A* a pasteboard protractor *D* is glued,

and a slit (E) is cut in B so that the circular divisions on D may be readily seen.

The perimeter is used as follows: place the end H upon the bridge of the nose so that the eye to be tested is in a line with the card F; have the patient close the other eye; move the arm B so that it is on the temporal side of the eye and at an angle of 90 with A. Instruct the patient to look steadily at the spot on F and inform you when the spot on G is also seen. Move B inwards until the patient reports having seen the spot on G. Note the circular degrees. Repeat for the nasal, and for the upper and lower fields. In the use of this instrument, the results in circular

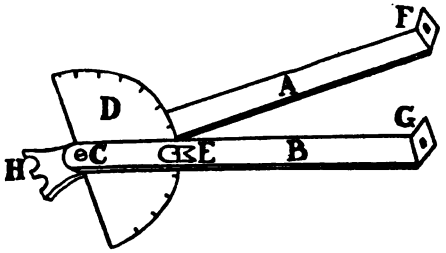

FIG. 2. Simple perimeter. A and B, arms; G and F, cardholders; D, protractor; E, opening for observing scale of protractor.

degrees are not exact, on account of the position of the pivoting of the arm B. The accuracy is, however, sufficient for the detection of constrictions of the field which are of diagnostic importance. For a more careful mapping of the visual fields the use of a more expensive perimeter is necessary.

(*c*) *Color Vision.*—In normal people with parts of the retina (the extreme periphery) colors are not usually sensed, or sensed only as gray; with other parts the red and green are not sensed; and with the central portion all the colors are sensed. Normal people differ, however, in their ability to see the colors at the extremes of the spectrum with the central as well as with the peripheral portions of the retina and there are, therefore, normal slight differences. A most marked deviation from the normal color sense is to be found in individuals otherwise normal, about one per cent. of women and about four per cent. of men being unable to sense green and red. Occasionally an individual is found who is unable to sense any color. Both of these condi-

tions are known as "color blindness," and are supposed to be due to a lack of functional development of the retina.

For the exact determination of the character of color blindness most elaborate apparatus is necessary, care being taken to use only unmixed spectral colors, but for the determination of the condition for practical purposes of diagnosis the Holmgren wool test is satisfactory. Place before the patient about two dozen skeins, including greens, grays, reds, etc., and request him to select the skeins similar to (not exactly like) the one (a red or a green, but not highly colored) you present to him. If, for example, he selects browns, grays and reds with the green as a standard, the patient is color blind, or has a color weakness, which for its designation may require more careful testing with many more colors. Similarly with red as the standard.

Another simple method is the Nagel card test.[2]

Hearing

All tests of hearing must be conducted in a quiet room, or the interferences from external noises will so vitiate the results that they are useless for diagnosis.

(*a*) *Auditory Acuity.*—The acuity of hearing may be roughly determined in the following manner. Place the patient at the end of a room and have him cover one ear with the corresponding hand and have the other ear directed toward the experimenter. Hold your watch in your hand as far from the patient as possible and instruct him to inform you when he hears the ticking. Move towards him and note the distance at which this is heard. Do this for each ear. See that the patient's watch does not remain in his pocket, and for precaution it is advisable to remove it and cover it with cloths at the other end of the room. During the test, cover the testing watch with the other hand and a handkerchief to deaden the sound for the "error test."

A similar test may be made by whispering, and having the patient report what was said. For this test it is best to use the numerals, but without informing the patient that you are doing so. This test is, however, unsatisfactory (and sometimes unsafe) in cases in which auditory hallucinations are prominent.

[2] For details see Whipple, Manual of Mental and Physical Tests, pp. 156–158.

This is on account of the interpretations such patients may make if the sounds are misunderstood.

Another similar test is with a tuning fork. The conditions in this test depend upon the character of the tuning fork, and must be determined by the experimenter.

(*b*) *Air and Bone Conduction.*—Place a vibrating tuning fork near the meatus, and when the patient can no longer hear the tone, place the handle of the fork on the mastoid bone or on the occiput. The results of this test will give some indication of the location of a defect of the auditory apparatus.

(*c*) *High Tone Range.*—Use a Galton whistle (see Fig. 3)

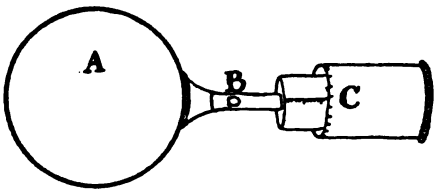

FIG. 3. Galton whistle. *A*, rubber bulb; *B*, whistle opening; C, piston scale.

and determine the highest tone the patient can perceive. Care should be taken that the patient hear a tone and not only the rush of air when the rubber bulb is squeezed. The results of this test are useful for determining cochlear disease, the lower portion of the cochlea containing the receiving apparatus for the high tones.

(*d*) *Direction of Sound.*—Seat the patient in a chair and have him close his eyes. Click two coins together in the imaginary plane drawn midway between the ears, and have the patient locate with the hand the approximate location of the source of the sound at different places (or use a practice sounder, see Fig.

FIG. 4. Simple practice sounder.

4). Normal individuals fail to locate well sounds produced midway between the ears, but the localization, with equal hearing ability of the two ears, is as often on the right as on the left. If there is a variation in the auditory ability of the two ears the

sound will more often, sometimes always, be located on the side of more acute hearing.

Smell

The testing of smell ability is difficult, on account of the large number of smell qualities and on account of the small smell vocabulary of most people. Unless smells are identified with definite objects (fish, orange, flowers, etc.) they are usually classed as agreeable, disagreeable, or neutral. Moreover, especially in a closed room, odors spread and after a few tests the stimulus is complex rather than simple. In the performance of smell tests care must be exercised that the corks of the bottles be kept scrupulously clean and for this reason the minimum amount of solution should be used in each bottle, and the material should be dropped into the bottle without touching the neck. The following well known materials are suggested:

(*a*) Sulphuric ether.
(*b*) Oil of cloves.
(*c*) Oil of peppermint.
(*d*) Oil of rose.
(*e*) Old fish.
(*f*) Carbon disulphide.
(*g*) Strong cheese.
(*h*) Asafetida.

The bottles should be covered with paper or painted on the outside so that the patient does not get information of the material through the sense of sight. The bottles should be uncorked individually and presented immediately to the patient and then recorked. Ask the patient to tell what the odor is, and also whether it is pleasant or unpleasant.

With some patients (who have smell hallucinations) it is well to make an "error test," using water or kaolin or other non-olfactory material as a stimulus, to determine the influence of the perceptory element.

Taste

In performing experiments upon taste ability, some knowledge is necessary of what the patient has eaten and drunk during the preceding part of the day. If substances with excessive gustatory and olfactory qualities have been taken the tests of taste ability

will be vitiated by the persistence of the former stimuli. Thus, onions often prevent the detection of the taste substances which are close to the threshold value, and alcoholic drinks (whether as whiskey, beer or even medicines) and tea interfere with accurate tests. It should be unnecessary to mention that drugs such as potassium iodide also affect the sense of taste, even though they be taken twenty-four hours previously.

Prepare bottles of watery solutions of sugar, 5 per cent. and 40 per cent.; of salt, 5 per cent. and half saturated; of quinine hydrochlorate, .002 per cent. and 1 per cent.; and of tartaric acid, 0.5 per cent. and 10 per cent. Have distilled water for "error test." Arrange the solutions into weak and strong series, and have medicine droppers fitted into each bottle. Instruct the patient to put out the tongue, drop one drop of a solution on it. Ask for a judgment. The next test should not be performed for two or three minutes so that the effect of the stimulation be masked by the residual of the first. This time interval is especially necessary after the stimulation with the bitter solutions. The weaker solutions are normally perceptible, the stronger should be sensed unless there be an ageusia.

Tendencies to taste hallucinations may be detected by the use of distilled water (which some normal people sense as "sweet"), of common water, and of normal salt solution (0.6 per cent. or 0.8 per cent. solutions). If distinctive tastes are obtained by the use of these, the fact is an indication of an hallucinatory tendency or of actual hallucinations.

Touch

For the determination of the normality or abnormality of the touch sensations the patient must be completely undressed and be lying upon a suitable couch or bed covered with a sheet or blanket. Throughout the tests the eyes of the patient are to be closed. Only the part of the body which is to be examined should be exposed at one time, especially in winter, on account of the possibility of the disturbance of the sensations by cold, etc. After the different parts have been examined individually it is well to expose larger areas of the body and to test in successive moments different parts, *e. g.*, the right hand, right chest, left chest, left arm, right abdomen, left abdomen, etc., in order that the patient be not influenced too much by auto-suggestion.

I have found it convenient to utilize a special number of points (95, excluding the head) in the routine examinations, in order to include all the important areas of the body (see Fig. 5), but other points may need testing in individual cases which show abnormality. If an hypesthesia or anesthesia be suspected, careful testing

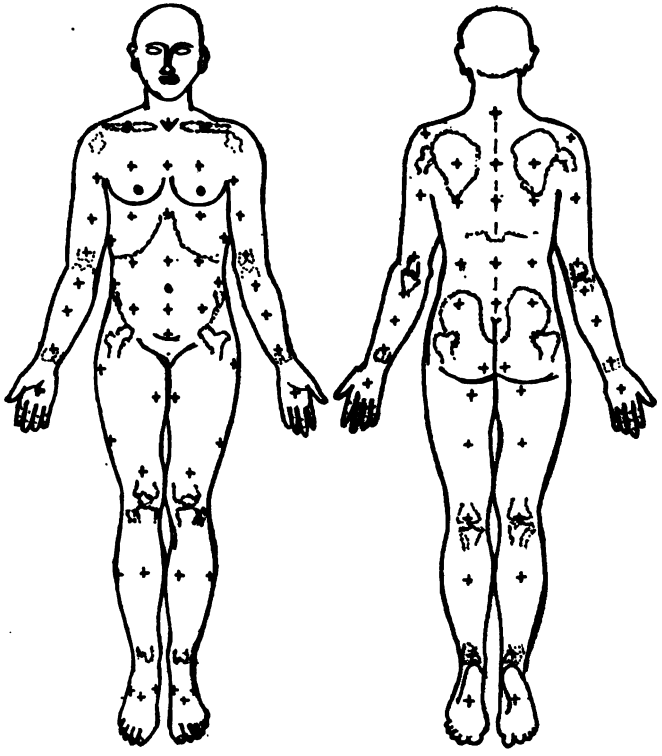

FIG. 5. Illustrating points selected for examination of skin sensibility.

and comparison must be made of this area with the corresponding one on the opposite side and with the neighboring areas.

In most of the tests for clinical purposes the punctate sensibility of the skin is not taken into account, although in more careful work this should be done. It is sometimes difficult for normal, well-educated subjects to recognize the different sensory points and for the abnormal, neurologically and mentally, it is sometimes impossible. If the subjects be only slightly educated tests of this fine character will be impossible. Details of these methods

and of the results with them are to be found in numerous works.

(*a*) *Qualitative Touch Tests.*—The method which was first employed by Head is for the qualitative or slightly quantitative detection of hypesthesia and anesthesia. Take a small piece of cotton wool and roll it into a loose wisp. This is to be lightly brushed over successive areas and the patient instructed to answer "yes" or "now" whenever he feels the stimulation.

Although cotton wool is convenient and sufficiently exact in many tests, it cannot be used for any length of time and must be replaced. In the replacement it is almost impossible to get another piece of the same weight and with the same bending pressure, and for this reason, in accurate work, the results obtained must be considered as having been obtained with different pieces of apparatus. For this reason I have used a camel's hair brush, from which most of the outside hairs have been clipped, leaving a brush containing about 125 hairs, 18 mm. long, and having a bending strength of from 100 to 200 mg. This instrument is much more constant than the cotton wool and may be utilized for the testing of many patients. The method of using the brush is the same as that for the cotton wool.

(*b*) *Touch Threshold.*—For more exact tests I have em-

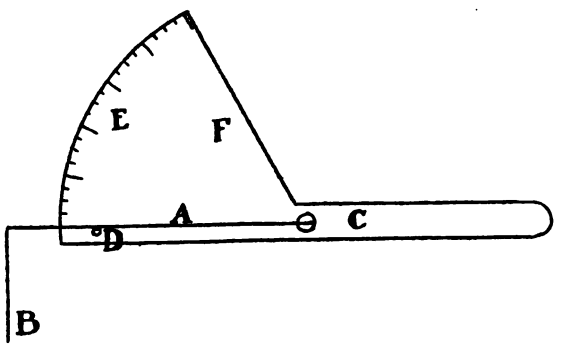

FIG. 6. Block esthesiometer. *A-B*, spring wire stimulant; *D*, supporting pin; *E*, scale.

ployed the touch instrument of Block, which is illustrated in Fig. 6. A piece of fine piano wire, *A*, is bent at a right angle and one end is soldered to a small screw, *C*. The length of the longer arm of the wire is 15 cm., and of the shorter, *B*, 5 cm. The area of cross section is 0.1 sq. mm. The screw is screwed into a piece

of wood, *F*, of the form indicated in the figure. A pin, *D*, is inserted to keep the wire from vibrating. The larger end of the wood holds a scale, *E*, divided into degrees, and the instrument is calibrated in terms of these. The instrument permits the giving of stimuli with pressures varying from 0 to 2,000 mg.

The end of the shorter piece of wire is pressed against the patient's skin and the pressure increased until he reports that he perceives a touch. Care must be taken to keep the wire, *B*, as nearly vertical as possible. The scale is read and the figure recorded. With this instrument the relative thresholds in different parts of the body may be determined and a quantitative estimate made of hyperesthesia as well as hypesthesia and anesthesia.

Similar tests may be made with the von Frey hairs, but the number of these necessary for the testing of any part increases the total number of experiments, without, for clinical purposes, giving any more definite information.

The touch weights of Scripture may also be employed, but these also require a greater number of tests, and the time for testing the whole surface of the body is too great for clinical purposes.

The touch hairs and the weights, especially the former, may be found useful for the more careful testing of smaller areas although they have only a theoretical superiority over the instrument of Block.

(*c*) *Localization of Touches.*—The accuracy of localization of touches depends upon a number of factors, the normal uses of the part of the body, the combination with other sensations, *e. g.*, those of pressure and pain, and the sensitivity of the part. For these reasons, touches are poorly localized on the back, abdomen, the legs, better on the arms, feet and hands, and best on the face or fingers. Those parts which are most sensitive, having a low threshold value, are the ones on which stimuli are usually best localized.

In abnormal conditions touches may not be felt (anesthesia) and consequently not localized, or may have an intensity less than normal (hypesthesia) and be poorly localized, or have an intensity greater than normal (hyperesthesia) and result in a poor localization on account of the intensity or the spreading of the sensation effect. In other abnormal conditions the stimuli may

be located in a neighboring part or in a corresponding segment (dyschiria and allochiria).

For stimuli, touches may be given with a wisp of cotton wool or with the camel's hair brush, if the sensibility of the part is nearly normal, or with the end of the finger or a pencil if the threshold value is high. Have the patient close the eyes. Touch him on a part and have him locate the point touched, either by pointing to it with a finger or on parts which he cannot reach by describing the location. In locating with the finger do not permit the patient to touch the part or there will result a confusion between the two stimuli.

(*d*) *Double Point Threshold.*—If two points 2 cm. apart are simultaneously applied to the skin, it is found that they are appreciated as two in certain regions and as one in others. The variations are as marked as those of the touch thresholds, and the parts which are most sensitive to light touch are also most sensitive in the appreciation of the two points.

Blunted compass points are commonly used for the stimulation of the areas, and a millimeter rule is necessary for noting the distance between the points. Apparatus has been devised to include both these, the most satisfactory for general use being that of Jastrow which is illustrated in Fig. 7. This instrument is made with a double screw so that the points may be set closer together or farther apart, and the upright has a sliding olive which

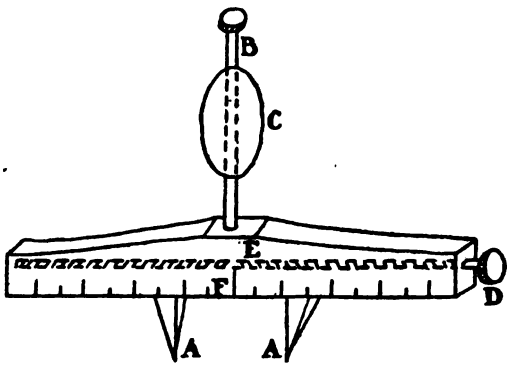

FIG. 7. Jastrow double point esthesiometer. *A-A*, stimulating points; *B*, handle; *C*, sliding olive on handle; *D*, set screw for double screw (*E*) moving points *A-A*; *F*, scale.

is to be used as a handle by the experimenter. When the points are placed on the skin the sliding olive prevents extra pressure by the experimenter, the only pressure of stimulation being the weight of the instrument.

Satisfactory results may be obtained by the use of a number of set stimuli by having needles inserted at definite intervals in pieces of soft wood, as shown in Fig. 8. For ordinary tests seven

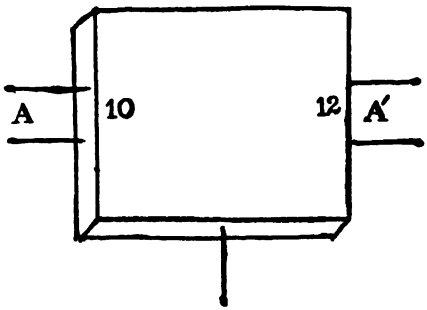

FIG. 8. Simple double point esthesiometer. *A-A*, needles at 10 and 12 mm.

of these are necessary, having the following distances between the heads of the needles: 2 and 4 mm. for the fingers and lips; 6 and 8 mm. for the fingers, tongue and face; 10 and 12 mm. for the hand, arm and face; 15 and 20 mm. for the hand, arm, foot and leg; 30 and 40 mm. for the arm, foot, leg and chest; 50 and 60 mm. for leg, arm, chest and abdomen; 70 and 80 mm. for leg, back and chest. On each piece a single needle should be also inserted. After the needles have been inserted in their proper places it is well to dip the eyes into melted sealing wax, immediately turning them with the eye upwards so that the drop of melted wax does not flow to a point at the stimulating surface.

The tests should be made in different regions in series of ten, five with one point and five with two. The above are sufficient indication of the instruments to use in testing individual parts.

In performing the tests care must be exercised that the two points are placed on the skin at the same time, because the double point threshold for successive stimuli, even when the time interval is very small, is not more than one half that for simultaneous stimuli. It is also necessary to have the pressure on both points the same in amount, otherwise the more intense stimulus will be felt and the less intensive not felt. In this way the results may

be vitiated even though the two points be placed at double the distance that is required when the two points are stimulated with equal pressures.

The tests with one and with two points should be made in an irregular order, so that the subject gets no clue to the objective characters of the individual stimuli, and for this purpose it is well to utilize one or more of the orders suggested in Chapter 12 (p. 162).

Temperature

When certain objects are placed upon the skin, sensations of temperature arise; and when others are placed upon the skin they produce no such sensations. It appears that the sensations of temperature depend upon the differences in temperature between the skin and the stimulating objects and, to a certain extent, upon the accompanying conduction of heat by the stimuli. It is for this reason that the sensations which are obtained from the stimulation by metal, glass, and wood objects and by other materials are different, for these objects have quite different stimulating or sensory effects. Materials such as hair or wool neither take nor give up heat rapidly; consequently, unless the temperature differences are excessive they feel neither warm nor cool. Metals, on the other hand, conduct heat rapidly and, consequently, unless their temperature be nearly the same as that of the skin they are felt as warm, hot, cool, or cold, depending upon the variations in temperature from that of the skin. Although glass and wood are comparatively poor conductors of heat they act like metal in that they receive and give up their heat when applied to the skin. When, however, the temperature of the layer close to the skin attains the temperature of the skin, either by loss or by accretion of heat, the temperature sensation ceases since the sensation is usually produced by an actual temperature difference. Metal objects, conducting heat rapidly from one molecule to another, keep up a rather constant stimulation, while objects made of glass, wood, etc., which do not rapidly conduct heat from one part to another, have, consequently, a stimulating effect which is of very short duration, because the stimulus persists only as long as the stimulation surface has a temperature differing by four or five degrees from that of the skin.

The use of the different kinds of instruments for determining

temperature sensation will depend upon the object of the test. In many tests it is advisable to utilize stimuli which are long continued. For these reasons the determination of the presence or absence of temperature sensation ability must depend upon the methods which are used.

On account of the possibility of confusion arising from the results, a fact that must be kept in mind is that the sensations resulting from extremes of heat or cold have similarities, and on account of the association of temperature sensations with those of pain, the subject may say that a cold object is hot or vice versa.

It will be remembered that the sensations of temperature, like those of touch and pain, are due to the stimulation of temperature points on the skin. This has been well shown by Goldscheider, by von Frey and by others. The cold spots are more numerous than the heat spots and their stimulation gives rise to sensations more quickly.

(*a*) *The Perception of Temperatures.*—Depending upon whether a stimulus of long duration or one of short duration would be most advisable, a metal rod or a test tube of glass filled with water are to be used respectively. If a long-continued stimulus is deemed advisable the stimulus should be applied to the skin and permitted to remain until the observer or patient reports that he feels the stimulus and makes a judgment as to whether it is warm, hot, cool, or cold. If a momentary stimulus is to be given, a glass rod may be used or a metal rod be placed for a moment on the part of the skin which is to be tested. The temperature of the stimulating object may also be varied. It has been shown that in normal people temperatures below 15° C. result in the temperature sensation of cold, from 15° C. to 25° C. in the sensation of coolness; from 30° C. to 40° C. in the sensation of warmth; and beyond 40° C. in the sensation of hotness. The absolute temperatures of stimuli will give, it must be understood, different sensations in accordance with the temperature of the part which is stimulated and the above figures are those for the skin exposed to the air. For careful testing it is necessary that each of these degrees be determined separately, and that the sensations of hotness, of warmth, of coolness, and of cold be investigated. For the usual clinical purposes, however, it is only necessary to have stimuli which are felt as "hot" and "cold" by the normal individual.

(*b*) *Punctate Temperature Sensibility.*—For the determination of the sensations of hotness and coldness from separate points in the skin one must utilize an apparatus (see Fig. 9) with sharpened point which is heated or cooled and applied to the individual points on the skin. In this way only a small portion of the skin may be gone over and for clinical purposes this is most tedious and unnecessary.

(*c*) *Temperature Difference Sensibility.*—Between the ordi-

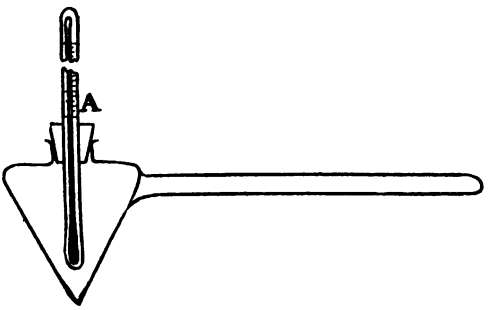

FIG. 9. Instrument for examining temperature punctate sensibility. *A*, thermometer for determining the temperature of stimulant.

nary temperatures which we feel as warm and cool, a difference of about 0.5° C. may be appreciated. In abnormal conditions the differences must usually be greater than this amount, and, as has been noted above, there are certain conditions in which hot and cold objects can not be differentiated. For determining difference thresholds use two metal rods or test tubes filled with water heated to definite degrees and varying from each other by approximately one degree C. Place one of these on the skin for a second or two, and after an interval of a second place the second stimulating surface on the skin for an equal length of time. Require the patient to make a judgment whether the first stimulus is warmer or cooler than the second.

PAIN SENSATIONS

The sensations of pain depend upon two apparently different factors, certain nerve endings in the skin, and others in the underlying tissues. The pain sensations which result from the stimulation of the skin depend upon the presence in that organ of nerve

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the end of the vertical part (*B*) be sharpened
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which for general purposes is that of Cattell, which is figured in the accompanying diagram (Fig. 10). This instrument may be briefly described as a compression spring, to one end of which is attached a rod with a stimulation surface which is placed on

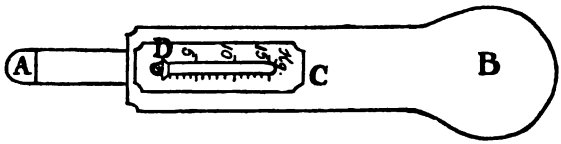

FIG. 10. Cattell algometer. *A*, hard rubber stimulating surface; *B*, handle; *C*, scale; *D*, scale pointer.

the skin. This stimulation surface has an area of about 25 sq. mm. The instrument is grasped at the upper larger end by the experimenter and the smaller stimulating surface is applied to the skin of the subject. Pressure is exerted by the experimenter and when the subject reports a sensation of pain the reading is taken from the scale which is marked in kg. On certain parts of the body an instrument with as heavy a spring as that used in the Cattell instrument can not be utilized on account of the low threshold value, because the scale divisions are not sufficiently fine. This is particularly the case in those parts of the body in which the bones approach the surface so that in the testing of such parts it is necessary to use a weaker spring or another

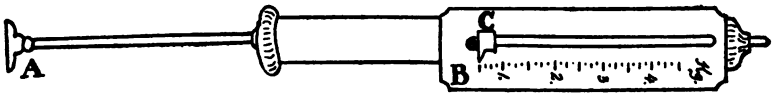

FIG. 11. McDonald algometer. *A*, stimulating surface; *B*, scale; *C*, scale pointer.

apparatus. The McDonald algometer (see Fig. 11) which has a weaker spring and a larger stimulating surface may be used for testing parts like the scalp, forehead, temples, or shins, although it must be understood that the results obtained by the use of this instrument are not strictly comparable with those obtained from the smaller surface of the Cattell algometer.

(*e*) *Tender Points or Areas.*—In certain cases areas of hyperalgesia are to be noted by the simple method of pressing upon different parts of the body with the hand or fingers. This method gives only rough qualitative results, and the results are further-

more complex in that the stimulation is given often to internal organs in addition to the skin and to the underlying subcutaneous and muscular tissues. Pressure on different portions of the abdomen may produce localized pains or a feeling of tenderness which is similar to that of pain. This is the method of the clinician in determining the so-called tender points and which is so useful in general clinical medicine. In tests like these care must be exercised that the localization of the pain is comparable with the location of the stimulus. In this connection the referred pains are to be kept in mind, since it is known that pain from disease or from pressure upon the thoracic and abdominal viscera is often felt in parts of the body at some distance from the part which is affected or stimulated. For details of this matter the reader is referred to the articles and works dealing with this particular topic.

Pressure

The sensations of pressure in normal subjects are combinations of the sensations of touch, temperature, pain, pressure and, probably, also motor sensations. Only in certain pathological conditions is it possible to have the sensation of pressure investigated apart from the sensations of touch, pain and temperature. In this condition the nerve or nerves supplying the skin have been injured or destroyed and the skin has become anesthetic or analgesic. The pressure sensations, however, may be investigated in normal people by keeping the other conditions constant, *e. g.*, the area of the skin which is stimulated should be the same in successive experiments, and the temperature of the objects utilized should also remain the same. It is found that when two objects of equal size are applied to the skin one will be judged heavier than the other if it exceeds in weight by approximately 12 per cent.

(*a*) *Passive Pressure.*—Prepare several sets of weights one having 100 gms., a second having 500 gms., and a third having 1,000 gms. as standards. Have the weights in one set of one size, but the three sets may differ from each other. In any set there should be at least six weights having the relation of 100, 104, 108, 112, 116, and 120. The smaller weights around 100 grams may be made by filling or partly filling shot-gun cartridge shells with cotton wool and lead shot until the weights bear the rela-

tion to each other suggested above. The larger weights, around 500 and 1,000 grams, may be made by filling tin pomade boxes with cotton wool and lead shot. Place one of the standard weights (100, 500 or 1,000 grams) on the hand. Permit it to remain about one second and then place another of the series in the same spot and require the patient to make a judgment as to which is the heavier. Tests should be made in an irregular order, sometimes the lighter and sometimes the heavier weight being placed upon the skin first. The method to be utilized in the establishment of the threshold value is noted in Chapter 12. That difference (whether it be between 100 and 108 or between 100 and 120) which is rightly judged 75 per cent. of the time is taken as the threshold value. Similar tests may be made on the face, on the arm, on the leg, or on the chest or abdomen. In these tests the subject should not see the weights and the eyes should be closed or covered with a towel or handkerchief during the tests. The part which is to be examined should remain perfectly passive and it is well in these experiments to have the arm or leg or other part supported. It is, of course, needless to say that in an attempt to make experiments of this character on the abdomen or other moving parts the results obtained are not entirely comparable with those in which the parts remain passive.

Motor Sensations

The sensations of movement depend upon impulses received from a great many parts of the body. Afferent impulses come from the muscles, from the joints, from cartilage, from bones and possibly from fascia. Except in certain rare pathological conditions it is impossible to differentiate these individual elements, so that in most cases we must deal with the combination of two or more of these. Furthermore, in individuals who are not anesthetic movements will produce afferent impulses which may, for example, result in sensations of touch and pressure. The presence or absence of the ordinary motor sensations may be determined in a rough manner by noting the movements of the individual in the performance of such acts as walking, standing, using the arms, buttoning or loosing the clothing, writing, etc. All the tests of motor sensations should for scientific purposes be conducted without clothing so that the sensations which are

received from the clothing may be eliminated, and the part which is being tested be kept separate from other parts. That the separation of the body parts in these tests is necessary will be recognized from the fact that the writer has examined a case of hematomyelia in which there was complete anesthesia below the 8th cervical segment, but the patient was able to tell (from the sensations from the head due to the shaking of the bed) when the legs were being moved.

(*a*) *Qualitative Tests of Motor Sensations.*—Have the individual undressed and lying upon a couch or moderately hard bed. Have the eyes closed; take hold of one member and move it in some direction; have the patient describe the movement and the part which is moved. For these tests it is necessary that the individual keep the part which is tested perfectly passive and that the movements be characteristic of the parts in this way. Movements may be made of the individual fingers, of several fingers at a time, of the hand at the wrist, of the arm at elbow and shoulder, and of the feet, toes, and legs at knee and hip. The various movements of flexion, extension, and rotation should be tested in this manner.

At times it is impossible to get the subject to describe accurately the movements which are made; often the description is so poor that only the general part of the body is noted and for this reason it is advisable in many cases to have the subject reproduce on the corresponding side of the body movements similar to those which have been produced by the experimenter.

(*b*) *Movement Sensations, Tests of Corresponding Members.*—A quantitative estimate may be made of the accuracy of movement of corresponding parts and of corresponding movements by an elaboration of the test just described. From the results in these tests an estimate of the relative fineness or normality of the movement sensations may be obtained. For these tests a rule divided into centimeter divisions and a protractor giving five degree divisions are needed. The central point of the rule is marked, and the subject is instructed to place his hands together so that this mark indicates the dividing line between them. The experimenter moves one of the hands to one side and instructs the subject to reproduce this movement with the other hand. A comparison of the amounts of movement gives an indication of the

accuracy of the movement sensations. This test may also be made by instructing the subject to move one hand and a second later to move the other hand in a corresponding way. Similar tests may be made of the leg movements with the foot as the indicator. In these tests care should be exercised that the subject makes the movements with corresponding parts, *e. g.,* at the hip on both sides in one test, or at shoulder in another test, etc., and that the movements are not simple on one side and complex on the other, *e. g.,* movement at shoulder on the right and movement at shoulder and wrist on the left, etc. For estimation of rotation, pronation and supination, the protractor is to be used in a manner similar to that of the rule. By the use of the protractor the accuracy of the various rotations may be determined, even that of the head.

(*c*) *Difference Threshold for Motor Sensations.*—Tests of the accuracy of motor sensations may be made by having the subject raise with the hand or other part of the body weights of definite masses. The weights which were suggested for the testing of pressure sensations may also be used in tests of this character. Provide a set of weights, of the same sizes, but differing in mass, as 100, 104, 106, 108, 110, 112. Two of these are to be presented to the subject at one time, the subject being instructed to lift one weight, hold it for a moment, put it down, lift the other, hold it in the same way, and put it down and make a judgment which of the two weights is the heavier. The difference which is correctly appreciated 75 per cent. of the time is taken as the threshold value. If it appears advisable, the tests may be made with different series of weights, as was suggested in the tests of pressure sensation, viz., 100, 500 and 1,000 gms., as standards. Normal individuals are able to determine differences in weight from the sensations of lifting when the weights differ from each other by as much as 6 or 8 per cent.

It should be unnecessary to note that care should be exercised that the subject does not gain information of the relative masses from sight and the two weights which are used in any test should have their positions altered behind a screen so that the subject does not see the order in which they are placed. In this experiment half of the time the lighter weight should be presented to the subject first, and half of the time the heavier weight should be presented first.

Tests of the motor sensations in this way may be made of the lifting movements at the wrist, and if the subject is intelligent also at the elbow and at the shoulder. Heavier weights are usually necessary for testing the motor lifting sensations of the foot and the leg, and these should have attached to them means for lifting the weights, such as a handle. In these experiments small tin buckets may be utilized, weighted to about 2 to 5 kg. with lead shot and cotton wool, as were the smaller weights.

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See also references 2, 8, 11, 12, 17, 19 (Chap. I) and 147 (Chap. XII).

CHAPTER III

MOVEMENT

There are as many movements of the body or of its parts as there are combinations of muscles or possibilities of combinations of the muscles in the body. All the movements have, however, been grouped into three general types in accordance with certain physiological contents of the movements. These three types are: *reflex, automatic,* and *voluntary.* All three types have elements in common, and it is at times difficult, if not impossible, to determine or to limit a definite movement to one of these classes.

The *reflexes* we need not consider. They are the movements which go on without voluntary impulses, and are of a definite, localized character and of a rather simple nature. These movements are, we know, controlled or altered to a certain extent by voluntary motor processes, and they may have the character of the automatic movements, which we shall now consider.

The *automatic* movements are movements which usually originate as voluntary movements, but which continue unconsciously as long as there is the appropriate constant or intermittent sensory stimulus. The best example of this type of movement is that of walking. This movement or series of movements is in the young child of an awkward conscious character. After having been performed a great number of times, *i. e.,* after a period of training, the movements need only to be initiated by the cerebrum and they are then carried on by the activities of certain lower centers. In his experiments upon the various kinds of reflexes, Sherrington has shown that the movements of this type may be carried on, and even initiated, by the spinal cord.

The *voluntary* movements are movements of the skeletal, or of the striated, muscles, which are produced by the definite action of certain of the higher cerebral centers. Movements of this type are very complex, or may be complex, when compared with the movements of a reflex character. They have not the general predictable character of the reflex or of the automatic movements,

and the movements of different individuals may vary greatly in the performance of a comparatively simple act.

It is usual to divide all movements into flexions and extensions. Special types of these are said to be the constrictions and the dilations, such as are obtained in the blood vessels, in the alimentary tract and in all sphincters. We must, however, add another class which we find in the intestines, viz., the pendular movements, which are due to the alternate contraction and relaxation of the longitudinal muscle fibers.

Most of the movements of the smooth muscles, *e. g.*, those of the stomach and of the intestine, have little concern for us in the neurological and mental examination of patients, and they are to be determined or estimated only in a very indirect manner. Although the sphincter movements are also to be estimated or determined only from certain secondary effects, such as the evacuation of the urinary bladder or of the rectum, the effects are more directly noticeable than the effects of the pendular and peristaltic movements. Certain special types of movement, those of the blood vessels and of the gastro-intestinal tract, are subjects to be considered in a general physical examination and will not be treated here.

Although it is common to divide the movements into flexions and extensions, such a division is made having in view only the segment or the limb of the body and not the muscles. All movements of a member are made up of the contraction (flexion) of one or more muscles and the extension (or relaxation) of others. Even movements of a simple type, such as reflexes, are constituted in this way, and it has been shown that all the movements which are initiated by the stimulation of the cortex have this characteristic. It has further been shown that when a certain muscle contracts from stimulation of the cortex its antagonist relaxes in an active fashion, not passively because of the pull of the contracting muscle. In a simple movement made up of the activities of two antagonists, such as the flexion of the leg, we find the flexion attended by a contraction of one or more muscles and by the active relaxation of another or other muscles, and we find the extension of the leg produced by the opposite conditions in the same muscles. We now know that the simplest voluntary movement is a complex of contractions and of relaxations of more or

less antagonistic muscles, and that no movement of the striated tissues is a simple, single contraction and relaxation.

Four factors in the movement must be considered: the *rapidity,* the *accuracy,* the *force* and the *extent.* Each of these may be deranged independently of the others, so that we may have slowings of movements, we may have inaccuracies, lack or losses in force, and limitations in the extent of movements. We most often have combinations of these, and commonly find that movements are slow, inaccurate, weak and of slight extent.

Speed of Movement

Although the speed of movement varies in individuals who are normal, and in the same individual at different times, it is known that most of the marked variations in rapidity are found in pathological conditions. The variations in speed are of two kinds, a quickening and a slowing. Much has been learned of the conditions in which the movements are slowed, but little information is at hand regarding pathological conditions in which the speed is increased. In the one pathological condition in which it is supposed there is an abnormal degree of speed in movement, viz., in mania, careful tests have failed to show any greater speed than the normal. In this condition what is supposed to be an increased speed, is really a quick shifting of the movement just as in this condition there is a quick shifting of the train of thought which gives rise to an apparent quickening of the mental processes. Both in estimating the speed of movement and the rapidity of thought there is an illusion. There are, however, many conditions in which the speed of the movement is much decreased. A characteristic condition in which this is a very prominent symptom is in one of the types of melancholia, viz., in the simple depression of manic-depressive insanity. In these cases, the lessening of the speed of the movement is spoken of as a retardation. Similar decreases in the speed of movement are also to be found in a number of organic diseases.

(*a*) *The Rapidity of Repeated Movements.*—One of the simplest methods of determining the speed of movement is to present to the individual a pencil and a sheet of paper, and request him to make a series of dots as rapidly as possible for a certain interval of time. The subject should be instructed to start and

stop at a signal and the time for the test may be varied in accordance with the individual experimenter's liking. In normal individuals, the number of movements or dots which can be made in a second, over a period of about 15 or 30 seconds, is from 4 to 8. Certain individuals who have occupations which require rapid individual movements, such as typewriter and pianist, may often go beyond the rate of 8 per second, but with the exception of these special cases 8 may be considered the normal maximum rate. It may also be said that 4 is the minimum rate which should be considered normal. This rate is seldom obtained in perfectly normal individuals, and therefore, in case an individual does not make as many as 120 taps or dots in 30 seconds the speed of the movement may be considered to be slow. This slowing in speed may be due to factors other than the inability of the patient to move a muscle or group of muscles rapidly, for it has been found in certain cases in which there is what has been called a diffusion of the attention.

In an experiment of this character the total speed may be reduced, but only for the series, while the subject may be able to perform the individual movements as rapidly as the normal if the movements be single and not serial. It has been said that even in cases showing the symptom of retardation the speed of the movement is normal after it has once been initiated and that the retardation is a slowing in the initiation of the movement.

(*b*) *The Rapidity of Repeated Movements.*—Another simple experiment may be made by presenting to the subject a pack of 50 cards (100, if the cards be very thin), and having him deal out these cards one at a time as rapidly as possible. The number of movements per second may be determined, and the time for the individual movements may be calculated from the total time. This test is of considerable value because of the possibility of comparison with other similar card tests which will be described later in the chapters on association, etc.

Tests *a* and *b* give the simplest method of approximating the reaction time, the accurate determination of which requires more elaborate apparatus and more time for instruction and performance than is usually available for general examination purposes.

(*c*) *The Time of Contraction and Relaxation in Repeated*

Movements.—A test similar to the tapping experiment described above may be made if a kymograph be available and by this test the time of the contraction and relaxation of the movement may be estimated. If, instead of starting and stopping the subject by command, a time record be made in conjunction with the tapping record we may also determine any degree of fatigue which results from the repeated movements. Arrange a battery in circuit with a recording magnet and an electric telegraph key. Have the marker attached to write a record upon the drum of the kymograph. Instruct the subject to tap as rapidly as possible upon the electric key. In this way a record of the time during which the key is held down and the time during which it is let up is obtained and one may then determine the amount of the time of the contraction of the muscles involved in this movement.

Instead of the electric key and recording magnet, a bulb and a recording tambour may be substituted. If these be filled with water and the connection be made with comparatively inelastic tubing there will be no appreciable lag of the apparatus and the times of beginning and of ending the contraction and the relaxation will be recorded.

We may also determine differences in the times of the separate movements during the first, middle and the later periods of a series of movements as well as determining variation in the period of contraction and of relaxation during these times. Both of these figures will give some evidence of the amount of fatigue which usually enters into experiments of this character. For normal subjects it has been shown that the greatest rate of movement begins after three or four seconds and that a fatigue effect, which is evidenced by a lessening of the number of taps, is perceptible after a period of ten seconds. This is for normal individuals; the abnormal, and especially the insane, show certain variations from these which have been taken by some investigators to be distinctive characteristics in particular diseases. If the rubber bulb and tambour be used there will also be noted a variation in the force of the individual movements during the course of a 30-second series of taps.

(*d*) *Speed of a Single Movement.*—If a kymograph be available the speed of the single movement may be estimated. As far as is known, this has no diagnostic value, although we have not

sufficient data at hand to say definitely that the speed of the individual movements does not vary in accordance with definite disturbances of the nervous system. For determining the speed of the individual movement the kymograph should be horizontal, revolving at its greatest rate and so arranged that the subject can write upon the kymograph directly with a pencil or stylus. The arrangement for these simple experiments is illustrated in

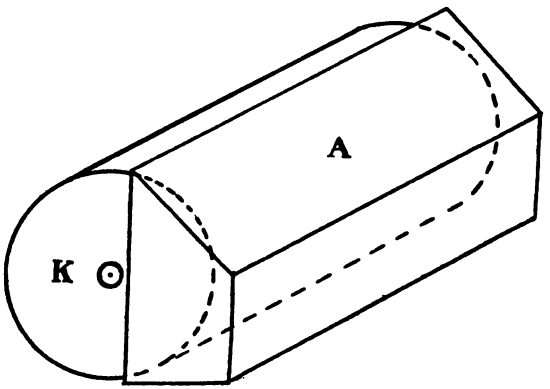

FIG. 12. Arrangement for test of speed of single movement. *K*, kymograph; *A*, hand and arm rest.

the accompanying figure (Fig. 12). *K* is the kymograph drum, and *A* is a large stand which partly fits over the drum and on which the hand and arm of the subject rest when the movement is performed. The end of the stand approaches rather closely the smoked paper. The subject should be instructed to hold the pencil or stylus at one end of the platform and to make repeated movements of a definite extent, the amount of movements in this case being limited by the length of the drum.

(*e*) *Qualitative Determination of the Speed of Single Movements.*—A simple method of determining the speed of single movements is as follows: Present to the subject a pencil and a sheet of paper; instruct him to begin at one end of the sheet and in a series of forward and backward movements to draw lines as quickly as possible rather closely together and to continue the backward and forward movements until told to stop. In this way continue for five seconds or longer. If the sheet of paper be large the subject may make as many as 25 double movements

(to and fro) and the rate of the movement may be roughly determined by calculating the space which has been traversed. Here, of course, errors of considerable magnitude enter. The changes in direction of the movements are the most important, but one may for comparative purposes disregard this error and may estimate the total amount of movement, and calculate from this figure, the rate per meter.

(*f*) *The Rate of Continuous Movement.*—Another simple method for determining the speed of movement is to present to the subject a circular piece of wood or a piece of wood on which a circle has been cut to the depth of about 2.5 mm., and request him to make rapid circular movements pressing a pencil or stylus around the edge of the circular block, or holding the pencil in the circular groove. It will be necessary to count the total number of complete movements around the circle in a given period of time, *e. g.*, 10 seconds. By multiplying the number by the amount of movement for a single trip around the circle the speed of the movement may be determined per second or per meter.

(*g*) *Speed of Movement of Different Parts of the Body.*—In the experiments first described the speed of movement of the hand and arm have been considered, but similar experiments may be made for the individual parts of the body, *e. g.*, the wrist, elbow, shoulder, and for certain movements of the foot and leg. Under normal conditions we expect to find the greatest speed, both in the performance of individual movements and in the performance of rapidly repeated movements, for the smaller muscles groups such as the fingers and wrists, and less speed in movements from the elbow and shoulder. The speed of movements for the leg and foot is in general less than for the arm. In performing experiments with the foot or toes it may be impossible to get the individual to grasp the pencil, but the tests may be carried out by the use of the electric key or the pencil may be fitted to the foot by a simple apparatus similar to a moccason.

Accuracy of Movement

In tests of the accuracy of movement, it has been found that not all parts of a movement are performed with the same speed. In all but the fastest movements there is, at first, an impulse which carries the moving member most of the way and after the initial

part of the movement has been performed there is another motor adjustment or there are more motor impulses to adjust and to make accurate the movement of the member which is being used. This is well shown in the curves which are obtained on the speed of movement (experiment *d*, page 41). An experiment in which the subject tries to make a movement of the same length as another movement brings out the interesting fact, which has been noted above, that the first part of the movement is rapid and that the latter part of the movement is comparatively slow. A curve which represents this type of movement is shown in the accompanying figure (Fig. 13). We find, in fact, that the first part

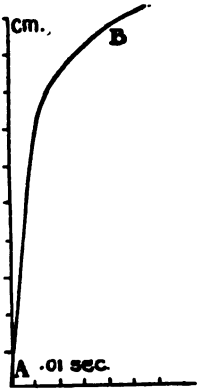

FIG. 13. Relation of time and extent in an accurate movement.

of the movement, in drawing a line for example, takes only about one tenth of the total amount of time for the making of the total movement although the extent of the first part of the movement is about three fourths of the amount of the total movement. The latter quarter of the movement takes most of the time as will be evident from the diagram. In any given accurate movement there is apparently an initial movement of considerable extent and after this there is an additional movement which is intended to make the total movement accurate. The experiment which has just been cited gives an indication of how experiments on accuracy should be performed. If sufficient time be allowed the subject, even though he be very unskillful, he will be able to make any particular movement fairly accurately. If, however, his skill or accuracy be slight, the performance of the task in a very short

interval of time will bring out evidence of this inaccuracy and unskillfulness. It is, therefore, advisable that all tests on the accuracy of movement be performed rapidly, the rapidity depending upon the general capabilities of the subject, but care must be exercised that the movement be performed with sufficient rapidity that the subject does not have much time for the latter part of the movement which is the part of adjustment. Careful tests of the factors influencing the accuracy of a movement have been made, and in a simple test like that of drawing a line, it has been shown that the accuracy of a slow as compared with that of a fast movement is as great as 9 to 1. Each movement in the tests to be described should be performed fairly accurately in one second or less.

It must also be kept in mind that practice influences accuracy. In certain pathological people a degree of accuracy is found greater than in most normal individuals. This is shown in the piano or violin player, who by practice attains a considerable degree of accuracy for certain types of movement, much beyond that found in most individuals, and who, in diseased conditions, may lose much of this accuracy, but still retain enough to excel normal people who have had no such practice. For this reason we must remember that, in testing individuals, we deal with relative amounts of accuracy and inaccuracy, and we may draw proper conclusions, and even make proper observations, only if we have knowledge of the previous life of the individual.

(*a*) *Qualitative Tests of Accuracy.*—The test of accuracy of movement may be made as follows: the patient, sitting up or lying down and with eyes closed, is instructed either to extend the arms to their greatest extent and then to bring one index finger rapidly to the tip of the nose. This arm should then be extended and the index finger of the other hand brought to the nose. This should be done for the two arms alternately and rapidly. A second experiment of this character is to have the patient fully extend the arms and then bring the fingers together in front of the face. The third experiment is to have the individual touch the ear on the opposite side of the head. With the legs one may perform a similar test by having the patient touch the left knee with the right heel, and vice versa. All these tests, it must be understood, must be performed with the subject's eyes closed.

Similar tests of accuracy may be made with the different members or with the corresponding parts of the body. The subject is lying down and the arms are in corresponding positions. Have the patient move the right arm in a particular way, outward, over or upward, and then have him reproduce on the other side a corresponding movement. The accuracy of the outward and upward movements for each side may be determined by a rule or a tape measure. A similar series of tests may be made with the legs. The feet are to be held widely apart. Have one leg moved inwards a few cm.; have the subject repeat the movement with the opposite side. Or, have the legs close together and have an outward movement made with one side, and this movement repeated with the opposite side. In this way, one may determine the relative accuracies of the sides. (See also motor sensations, experiment *b*, page 33.)

(*b*) *Quantitative Tests of Accuracy of Movement.*—The quantitative tests of the accuracy of movement of the arm may be made by having the subject draw on a sheet of paper a line equal in length to one which is shown to and held about 40 cm. away from him. After he has drawn the first line, turn the paper down so that this line is not seen; have him draw a second line and turn it down; draw a third line and continue this process until ten lines have been drawn. The calculation of the length of the lines which have been drawn with their variations (see Chapter 12) will give an estimate of the accuracy of these movements. Similar movements may be made in intelligent subjects at the wrist, fingers, elbow and shoulder. The tests of a similar character for the legs are much rougher and have been described in the preceding section.

(*c*) *Accuracy of Aiming Movements.*—Other experiments to test the accuracy of movement may be made by presenting to the subject cross section paper (about 2 mm. each square) and have him mark one dot each in one hundred of the consecutive squares. The rate of movement should be kept constant, one in half a second. The number of errors (*i. e.*, number of squares which have been missed) gives an indication of the accuracy. A similar test may be made by drawing on a sheet of paper three dots which form the apices of an equilateral triangle. The subject is instructed to hit these dots successively in regular order, one

every half second. The error (the inaccuracy) is to be determined by the variation of these dots from the point or points which are to be hit.

(*d*) *Accuracy of Throwing at a Target.*—A similar experiment of a qualitative nature may be made as follows (see Fig. 14). A target board, in which there is a circular hole 15 cm. in diameter, is placed against the wall of the room and the subject is presented with ten golf balls or ten large marbles which are to be thrown into the hole. Most normal people are able to throw six out of the ten in the hole at a distance of two meters (*i. e.*, from the hand to the target) and all are thrown into the hole at

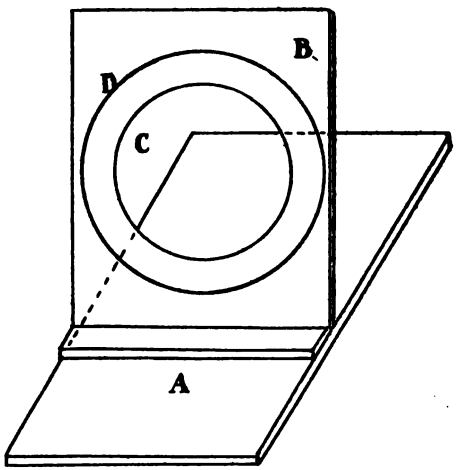

FIG. 14. Target board. *A*, base; *C*, opening; *D*, outside ring for estimating other than errors of throwing into target opening.

one meter. If more than the normal number of mistakes are made at these distances, the inaccuracy may be expressed in percentages of the normal. In tests of this character men are (from practice) more capable than women, and normal men usually are able to throw six of the ten balls into the hole at a distance of two meters and all at a distance of one meter.

FORCE OF MOVEMENT

Variations in force of movement are more easily tested, although not as accurately determined as those of speed and

accuracy. The force appears to be independent of the accuracy and of the speed, but the amount of work which is performed does depend, of course, largely upon the speed of the individual movements. For the purpose of testing the force of movements both qualitative and quantitative tests may be made. The quantitative tests of force are limited, however, because of the lack of appropriate apparatus for the determination of the activity of individual muscles or of groups of muscles so that in the testing of individuals we must rely more upon the qualitative tests than upon the quantitative ones if we are to examine all different parts of the musculature. Variations in force of movement are considerable. We have the exaggerations due to exercise, such as the muscular development of the athlete; we have the pareses due either to disuse or to disease, and at the extreme we find paralysis. It must be understood that in all these variations the extent may be different. There may be found an extensive distribution throughout the body, or, on the other hand, the variation may be limited to small groups of muscles or to single muscles. We must also remember that the previous occupation of the individual affects in a general way the motor power and in the testing of individuals the previous occupation must be kept in mind. In most people the right is the stronger side, although we have marked deviations from this. On account of the general rule a weakness on the right side should always be regarded as suspicious. The inequalities of movement force, may, however, be caused by disuse of a certain group of muscles in certain occupations. Even though an individual may not be left-handed the continued use of that hand to the exclusion of the right in the performance of certain tasks may result in an inequality in force of the hands or arms. Again we find inabilities to produce forceful movements in corresponding members at the same times (asynergia, a special kind of which condition has been called adiadokokinesis).

(*a*) *Force of Corresponding Muscle Groups, Qualitative.*— The force of movement of corresponding groups of muscles may be determined for clinical purposes by having the subject perform movements of the corresponding members forcibly and against the motor power of the experimenter. The subject should be undressed and unhampered by covering or clothing of any kind, and should be instructed to make corresponding movements with

the different parts of the body which are being tested. The experimenter opposes these movements, and, if in this test opposition is made by the experimenter with his right and left arms corresponding with the right and left sides of the subject, a force estimation may be obtained of the relative strength of the different segments of the body. In this way we may test the flexion and extension powers of the individual fingers, of the hand in grasping; of the wrist; of the elbow; shoulder; foot; knee; thigh; and head; the side way movements of the head, shoulders and thighs, and rotations of the arm at shoulder, of the leg at hip, of the wrist and ankle and of the head. Any marked difference in power of the two sides should be carefully tested by more accurate measures.

(*b*) *Quantitative Tests of Force of Movements of Individual Groups of Muscles.*—For the purpose of determining the actual force of movement, various pieces of apparatus have been devised which are commonly known as dynamometers. The most common instrument of this kind is the oval dynamometer, which is useful for determining the strength of the grip. In presenting this instrument to the subject he should be instructed to make as forceful a grip upon the instrument as is possible. This should be performed when the arm is freely extended from the body and care must be exercised that he does not place the hand on the thigh or the arm against the body. After one determination has been made with one hand, the instrument should be shifted to the other hand and a similar test made. Second and third tests should then be made alternately with each hand. The force of movement is sometimes found to be greater at the second or third squeeze of the dynamometer and the most forcible of the movements should be considered to be the force of the individual. This instrument may also be used for determining the strength of the outward movements of the arm at the shoulder by having the patient hook his middle fingers at the ends of the dynamometer and pull in each direction away from the instrument. The instruments (which are commonly made abroad) have two scales, an inner and an outer. On the outer the word "traction" is engraved, and on the inner "pression." The inner scale is to be read for the pressure with the hand, *i. e.*, the strength of the grip, and the outer for the traction, *i. e.*, for the strength of the

shoulder. Various other dynamometers have been devised for the determination of the strength of other individual parts, and there may be obtained an instrument for the determination of the motor power of the muscles of the back, that of the thighs and that of the arms in ways different from the movements which have already been described. These instruments usually require special places and are more expensive and for these reasons are not so universally used.

(*c*) *Fatigue of Movements.*—In testing the strength of muscle groups it is found that after one or two contractions of a particular group of muscles the force of movement tends to decrease. This phenomenon is commonly called fatigue. It may be tested readily by the use of the oval dynamometer which has been described above. The patient must be instructed to make forcible movements upon the dynamometer at regular intervals, say every two seconds, and the experimenter will read from the scale the force of the individual movements. These must be recorded. In this way it will be found that after one or two movements the force of the individual movements decreases and that after 20 to 30 the force is only about 50 per cent. of the amount it was at the beginning.

Special instruments for measuring the fatigue of movement may be used, but these require considerable time and often much subsidiary apparatus so that they are not available for clinical purposes.

The Extent of Movement

There is a normal extent of movement that may be performed by a group of muscles. This amount depends upon the character of the joint about which the movement is made, and also upon interfering structures. The amount of this movement may be expressed in terms of circular degrees and within comparatively narrow limits this method of determining the extent of movements is very accurate. The joints in normal individuals permit slight variations in the extent of normal movements, but the differences are so slight that we may disregard them, and we may say that all normal individuals have approximately the same capability of movement about the joints. We have, however, no carefully collated tables giving data of the normal amounts of individual movements, but usually the comparison of one side of an

individual with the other side will suffice. Since this comparison can be made readily we are able to judge whether or not one or the other side is limited in its extent. At the same time the comparison of different individuals with each other may be made.

The most common form of abnormality in the extent of movement is that of limitation. Limitations may be due to contractures, to rigid joints, to myotonias, and often to pain due to pressure upon nerve endings in or nerve trunks between the muscles or at the joints. On the other hand, we occasionally find conditions of hyperextention in which the possibility of extent of movement has been increased. This is common in those conditions in which the tonicity of the antagonistic muscles has been decreased so that we find it in some conditions of paralysis and very commonly in tabes dorsalis.

(*a*) *Extent of Movement.*—The extent of movement may be determined by having the patient raise the arms, rotate them, flex them, extend them; rotate, flex, extend, and turn from side to side the legs at each joint. In this way the comparative amount of movement on the two sides may be estimated. If a more careful test is needed, a large protractor may be adjusted near the joint at which the movement is made and the determination of the extent of movement may then be made in terms of circular degrees. This latter is usually not necessary, since the extent of movement may be determined readily by comparison of different individuals, and by comparison of the two sides of any particular individual.

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See also references 8, 17, 19 (Chap. I) and 147 (Chap. XII).

CHAPTER IV

SPEECH AND APHASIA

In the broadest sense speech is defined as the motor expression of ideas and the interpretation of another's movements into ideas. All movements we make which another may interpret as the indication of ideas, and all our perceptions of the movements of another which we interpret as the expression of ideas in the other individual are elements or parts of the speech process. At first, it might seem that speech must necessarily imply the presence of two individuals, the one making the expressive movements and the other interpreting these movements, but this is not always true. One individual may be both the mover and the receiver, and may carry on the speech process with himself. It is true, however, that speech is largely a social process and that we are dealing with a social consciousness most often when we deal with the speech function.

Some would limit the speech function to the voluntary motor expression of ideas and to the interpretation of these by another, but it is not necessary that the person experiencing a sensation or a feeling wish to convey the knowledge to another. It is only necessary that the movement which he makes be correlated with the mental state he is experiencing. Some limit the speech function to the motor expression given by those muscles under the control of the will, but even this is not necessary or advisable for we commonly find that certain of the involuntary or reflex movements indicate most clearly the presence of an idea or of a feeling, and in so far as another may rightly interpret the reflex expressions the process is speech. For example, the exclamation "Oh!" when given in a certain tone of voice, clearly conveys the idea of pain or of some shock, but the expression is reflex in character and may not be intended in any way to convey an idea. Other reflex mechanisms give clear indication of ideas and are often idea-expressors. A reddening of the cheek is interpreted as the concomitant of a feeling of shame, or of a sensation of heat, and the blanching of the skin is often an expression of a

feeling of fear or of anger. These are as much and as important methods of expression of ideas as those which are produced by the action of the voluntary muscles. The smile, the frown, the unfocused eye and the dozens of other involuntary movements are means of communication. They are movements which can be interpreted as idea expressions.

It may also be pointed out that voluntary movements which are intended by one individual to carry ideas to another, do not necessarily bring this about. The movements of the Oriental in vocalizing and in writing are not interpreted by the Occidental. There is an interpretation that the former wishes to convey ideas, but the ideas produced in the mind of the Occidental by the movements of the Oriental are not those which the latter wishes to convey.

Furthermore, the actual movements need not be seen, but it is very necessary that the results of the movements be sensed and interpreted. The movements of the diaphragm and the intercostal muscles, of the larynx and of the lips give rise to air vibrations which are perceived and interpreted. Other movements of the body may not be seen but the results of these movements (*e. g.,* writing or printing) may be the stimuli which another receives and interprets in a proper manner.

In a more limited way, however, speech is defined to be concerned with only a limited number of kinds of movements and to be indicative of sensations obtained from the stimulation of only a few of the sense organs. The movements of the hands in writing, of the lips and the vocal cords in vocalizing, and the sensations obtained through the eyes and ears have sometimes been considered the only parts to be concerned with the production and with the understanding of speech. It is recognized, however, that although these parts of the body are often used for idea expression and for interpretation, we must also deal with other parts, and must consider all the means of conveying ideas and all the means of acquiring information of the mental state of another. The deaf-dumb-blind individual who feels your lips when you are talking gathers information through the senses of touch and of movement and pressure, and he may rightly interpret your ideas.

When the speech function is considered carefully we see that we mean by the term certain mental and cerebral associational

processes, and when we speak of aphasia we mean the disturbances in associational speech mechanisms. A paralysis of the right arm, for example, which is accompanied by an inability to write may be called a motor form of aphasia, *i. e.*, an agraphia; a blindness due to some peripheral cause or causes is accompanied by an inability to see writing, printing and objects, and it might be called a form of sensory aphasia, *i. e.*, alexia; the paralysis of the muscles of the mouth, of the vocal cords, etc., results in the inability to vocalize, and might be called a motor aphasia; and deafness due to any cause, peripheral or central, with a consequent inability to understand spoken words might be called a form of sensory aphasia, *i. e.*, word deafness. We do not, however, use the term aphasia for these defects. Although each of these lesions produces a condition in which the speech function is interfered with we do not use the word aphasia to connote that condition.

The speech process is a process of association, and we properly use the term aphasia only for those conditions in which part of the association mechanism is interfered with to such an extent that the understanding of another's actions, or of another's vocalizations, or of the results of another's actions, such as printing or writing, is not normal. We also use the term aphasia for the designation of the association disturbances which do not permit the individual to express his ideas by means of writing, vocalization, etc.

For a proper conception of speech and its disturbances it is necessary to have a conception of the general mechanism of the brain, and especially of the associations, in a physiological sense, which go on in that organ. It has usually been deemed sufficient to consider that the brain is made up of parts which are concerned with certain sensory processes, other parts concerned with the production of movements, and still other parts which are concerned with the production of associations, or with the binding together of the sensory and motor parts of the brain. This conception of the mechanism of the brain is inadequate, for it assumes that a lesion in the hearing center, for example, may produce an aphasia. It is recognized that such an individual may not understand certain kinds of speech, but it is, as has been said, not the best way in which the term aphasia is used. Such a con-

dition is properly called deafness with an inability to understand all sounds as well as words. There has undoubtedly been a disturbance in the association functions of the brain, but these disturbances are comparable—in as far as they affect speech—with the motor disturbances that accompany the section of the nerves of the arm with a consequent inability to write voluntarily, or to copy, or to perform other movements which make up motor speech by hand and arm movements.

The functional pathological conditions following lesions of the different parts of the brain are sufficiently varied, and sufficiently exactly observed for certain areas, that we are able to form a more definite conception of the cerebral mechanism than that of the division into motor, sensory and associational areas. It is believed that closely connected with the so-called sensory areas, we have areas to which the sensory areas discharge, and which have been called perceptive or perception areas. These have been delimited to some extent by the histologists, as well as by the clinicians and they are to be considered closely connected with, but different from the sensory areas. In the same way there have been investigated areas the stimulation of which produces complex movements of a type different from those following the stimulation of the simple motor areas, and these two areas must be considered areas for the production of different types of movement. There are also areas which have neither direct sensory nor motor connections, but which are connecting lines between the sensory or perceptual and the motor areas.

The speech mechanism is the functional connection of the sensory (and perceptive) with the motor through the association areas. The number of possibilities of connection is very great, from one sensory area probably more than a thousand, and it is possible that the number of different kinds of aphasia is the same as the number of different possibilities of speech association mechanisms. To understand this it is necessary to consider only the simple combinations (associations) on the sensory side which may result from the stimulation of a sense organ by an object (to be seen or heard, etc.). A visual stimulus for example, may bring about associations (*a*) with other visual, (*b*) with auditory, (*c*) with olfactory, (*d*) with gustatory, (*e*) with tactile, (*f*) with temperature, (*g*) with pressure, and (*h*) with movement sensa-

tion ideas. On the other hand, each of these associations, or combinations of these (*e. g.,* visual-auditory-gustatory), may give rise to impulses for the production of several different types of movements: (*a*) of grasping and using, (*b*) of the vocalizing organs, and (*c*) of the hand and arm in writing. There is a possibility that any one of these mechanisms may be disturbed to such an extent that the normal associations can not take place and in that way a small limited aphasia results. In practice, however, it is found that lesions of the brain are more extensive than those which produce one special mechanism disturbance, and that usually many of these are affected at one time. We are, therefore, able from the examination of the clinical material to group the cases of aphasia into a few general classes, and the attempt has been made to correlate these general types of aphasia with certain areas.

The following individual forms of aphasia (with the losses which correspond) have been described by Wernicke, Lichtheim, Liepmann, *et al.*

1. Cortical motor aphasia: loss of spontaneous speech, of the abilities to repeat, to read aloud, to write spontaneously and from dictation.

2. Transcortical motor aphasia: abilities to speak voluntarily and to write.

3. Subcortical motor aphasia: abilities to speak voluntarily, to repeat and to read aloud.

4. Cortical sensory aphasia: abilities to understand spoken language, to repeat, to read aloud and to one's-self, and to write from dictation.

5. Transcortical sensory aphasia: ability to understand vocal speech and writing.

6. Subcortical sensory aphasia: abilities to understand vocal speech, to repeat and to write from dictation.

7. Conduction aphasia: abilities to repeat, to read aloud and to write from dictation.

8. Alexia: ability to understand written and printed matter.

9. Alexia and agraphia: the abilities to write, and to understand written and printed speech.

10. Agraphia: ability to write.

11. Acoustic agnosia: ability to understand spoken language and other sounds (*e. g.,* music, the noises of animals).

12. Optical agnosia: ability to understand things seen and their uses.

13. Tactile agnosia: ability to recognize objects from touch, etc.

14. Ideokinetic apraxia: abilities to perform certain movements voluntarily and to imitate movements.

15. Ideatonic apraxia: ability of voluntary innervation.

16. Member (Glied) apraxia: ability to perform certain fine movements, *e. g.,* whistling.

These forms of aphasia are seldom pure, *i. e.,* seldom sharply separated from each other, and the number of different kinds of aphasia is limited solely by the possibility of combinations, and by the extension or the discreteness of the cerebral lesions. Although these sixteen different clinical forms of aphasia have been recognized, they have been grouped into even fewer forms, and it is common to speak of all the aphasias as sensory or motor, depending upon the loss-prominence of one of these two elements in the condition. Not all aphasic conditions, however, conform to the different forms which have been described, for the individual differences must be taken into account, both in psychological and anatomical structure. It is, therefore, sometimes impossible to pigeon-hole a certain case into one of the sixteen compartments on account of slight difference in the cerebral functional relations of different individuals. It is also well known that certain of the associations may be lost by an individual and other similar ones retained. Cases of this character have been observed which indicate clearly the impossibility of a diagnosis in any but the most general terms. Such a condition is that of paraphasia. Here the patient is able to talk, but his talk is jargon, or is fairly correct except for the use of occasional wrong words. At times he is able to recognize the fact that wrong words have been used and at times he is not able to do so. On the whole he retains a fair ability to express himself, but it can not be said that his ability of association between the movements of speech and hearing is intact or good, nor is it possible to say that this ability is lost. It has been interfered with to some extent.

One more thing must be considered in relation to speech, viz., the suggestion of Marie that all speech disturbances are of the nature of dementia. This is a matter which has been attracting considerable attention during the past few years, the settlement of which depends entirely upon the conception we have of de-

mentia. If by dementia we mean a condition in which there have been lost certain normal associations, the terms dementia and aphasia may be used to designate the same condition. We are equally justified in defining dementia as the inability to form certain associations, and from this point of view we have the right to say that the loss of the right arm produces a dementia. It makes no difference that the loss of one arm may be followed by the education of the other, for we also find that a right-handed patient with agraphia can be taught to use the other arm for the purpose for which the right side was previously used. The discussion appears to be academic and of little or no value for the understanding of the processes in speech. What must be done for the understanding of aphasia is a more careful examination of cases, with finer analysis of the speech elements which have been lost. What should not be done is to conclude that all the important facts that can be learned have been learned and that it is only necessary to examine a case sufficiently well to be able to make a diagnosis.

Any individual suspected of a speech disturbance of the nature of aphasia should have a certain number of tests made, the number depending upon the character of the disorder. More are needed for the elimination of certain of the sensory disturbances than for the motor, because there are apparently more sensations involved in speech than there are motor elements. The following is considered the minimum of tests which should be performed for the purpose of a careful diagnosis:

(*a*) *Voluntary Speech.*—Note what the patient says voluntarily; whether or not he is able to carry on a conversation and how well and to what extent this can be done; whether or not he is able to make his wants known. At first, ask simple questions containing one idea and later those in which there are many ideas clearly connected. Questions should be asked relative to himself, to his occupation, and to other less familiar things. Get him to name objects, and compare the ability to name those which pertain to his business, or profession and those which are less familiar. (Aphasia types, 1, 2, 3, 4, 5, 6.)

(*b*) *Reading Aloud Printed and Written Words and Sentences.*—In testing for this function it is advisable to give to the patient a newspaper or magazine clipping pasted on a piece of cardboard. At times the inability to read aloud may be due to a

lack of sensory appreciation of the stimuli, and it is therefore necessary to present the clipping upside down, in order to see whether or not the patient recognizes the abnormal condition. (Aphasia types, 1, 2, 3, 4, 5, 6, 7, 8, 9.)

(*c*) *Writing Spontaneously, Name, Date, Address* (1, 2, 3).

(*d*) *Writing from Copy, Drawing from Copy* (1, 2, 3, 4, 5, 6, 8).

(*e*) *Writing from Dictation* (1, 2, 3, 4, 5, 6, 8, 9).

(*f*) *Repeating Words, Syllables and Letters which are Spoken* (1, 2, 3, 4, 5, 6, 7).

(*g*) *Reading, not Necessarily Aloud, Printed and Written Words, and Indicating by Actions, Speech or Otherwise, that the Stimuli have been Taken in and Understood.*—See (*b*) above (4, 5, 6, 7, 8, 9).

(*h*) *Performance of Acts in Accordance with Simple Commands, e. g.,* stand up; put your hand on your forehead; give me your hand; open your mouth; close your eyes; move your left leg. Other questions to determine understanding ability: Do you understand me? Would you like a cigar? Do you wish to go home? Did you see your husband yesterday?

Exhibit five articles on table, and ask the patient to select one or two. In the same way with words, colors and numerals. Ask patient to show 3 or 4 figures, to pick out 5 or 3 colors, etc. Show colors and ask which color is like that of grass, ripe tomato, lion, brick, etc. Make sounds like animals and have patient indicate appreciation (4, 5, 6, 7, 11, 12).

(*j*) *Recognition of Objects, and their Uses.*—Place in the patient's hand (and do not let him see it) one of the following articles: a key; lead pencil; spoon; small towel; piece of paper; rubber band. Ask patient to name it. Ask: Is it a handkerchief? Is it a pencil? etc. Try for each hand. Show object, *e. g.,* a hat, and ask, What is it? Do you drink from this? Do you write with it? Do you wear it? Get patient to show how one or more of the following is used: hat, pencil, scissors, cigar, match, etc. (4, 5, 6, 11, 12, 13, 14, 15, 16).

(*k*) *Mark Figures on the Skin* (cross, circle, letter, etc.), but do not let him see the marking. Ask what they are, get patient to draw or select from pictures which are shown (1, 2, 3, 9, 10, 11, 12, 13, 14, 15, 16).

In all these tests it is assumed that no sensory disturbance to interfere with perception and no motor disturbance to interfere with the reaction, are present. If a paralysis exists, the reaction by speech, in nodding the head, or the movement of the other hand, or even the look of the eye, as the case may be, must be taken as an answer to the question. If a sensory disturbance (anesthesia, blindness or deafness) exists, the tests in this special sensory field must be omitted, except that the disturbance as such should be investigated.

Speech defects, other than those of the nature of aphasia, must be determined in much the same manner, but usually voluntary speech and the ability of repetition of words and phrases are sufficient evidence of the character of the disorder (dysarthria, etc.).

The consonants are divided into the following 3 classes:

d, l, r, s, t, for tongue.
b, f, m, p, w, for lips.
ch, g, t, k, ng, for palate.

(*l*) Note any form of slowing, scanning, stumbling, hesitation, stuttering, or slurring. Test with words and phrases: electricity, conservative, statistical, irretrievable, perturbation, autobiography, perpendicular, around the rugged rock the ragged rascal ran, truly rural, tit-a-tat, giggling girls, third riding artillery brigade, etc.

(*m*) In estimating the speech ability or in diagnosing the speech defect of the patient the examiner must ask himself the following questions and keep in mind the following hints:

Are there twitchings of the facial muscles, of the lips, while the patient is speaking? Are there tremors? Do these affect the speech to an extent that may produce a condition somewhat like a jargon aphasia?

Does the patient understand what is said to him? How readily? Does he obey simple commands? If not, is it because he does not understand you or is it because he will not? If he obeys simple commands, does he perform the more complex ones as readily, *e. g.*, walk to the other end of the room, turn around quickly and walk back; turn your chair around, sit down and cross your legs. Differentiate between the inability to under-

stand, and the inability to remember three or more ideas at one time.

Does he correctly read aloud words, numbers, sentences, etc.? Has he been educated so that this would have been possible if he were not abnormal? If he does not correctly name colors, differentiate between color blindness and the inability to find the name for a common color. Does he have a tendency to repeat certain words and do certain words recur during the examination giving the speech the appearance of paraphasia? Is this a true paraphasia or a perseveration phenomenon independent of a speech defect?

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CHAPTER V

ATTENTION, APPREHENSION AND PERCEPTION

Although in general we understand that all stimuli which reach the sense organs have an effect, we know that all the stimuli are not appreciated and that they do not reach consciousness. Only a comparatively few of the stimuli which we receive daily are taken in and result in reactions. Of the stimuli which reach the body and are taken in, some produce effects greater than others, and we say that some are attended to and some are disregarded.

The taking in and the not taking in are due to the attitude assumed by the subject and this attitude has been called attention. Attention is not one of the subdivisions of mind, it is not a mental state or event of a character like a percept, and it is not a process coordinate with such mental processes as emotion, will, association and memory. James has defined attention as "the taking possession by the mind, in clear and vivid form, of one out of what seem several possible objects or trains of thought." It is the focusing of consciousness on some particular situation or thing. This is the definition of concentrated attention, but there are all degrees of gradation from the concentrated condition to that of absolute failure to attend to any one thing. Attention is, however, not continuous, but it is the fluctuating condition in consciousness. It may properly be spoken of as the summit of the wave of consciousness, this high point being wherever and whenever some special situation or object is focused and vividly presented to us.

In general we may say that attention is the having of one experience in a vivid form. This experience or the presentation may be a complex as far as the sensory elements are concerned, but as long as the thing may be apprehended as a whole it can be attended to as a whole. A horse, for example, may be attended to as a whole, but when we wish to examine the head we do not attend to the feet, and when we are attending to the size we can not and do not attend to the separate parts of the

whole. If we wish to attend to one element, we lose for the moment the clear perception and the vivid appearance of other elements.

Even though we try ever so hard to keep a presented situation of a constant vividness, *i. e.*, in the focus of consciousness or in attentive consciousness, we find it impossible to do so for any considerable length of time. The vividness wanes and waxes, we now see or have the experience in a vivid form, now it becomes less prominent. This condition is most noticeable when we try to attend to stimuli of little intensity. Constant stimuli which are near the threshold value may sometimes be appreciated, sometimes not.

Two stimuli may be given at the same time and only one have an effect upon consciousness. If a green light stimulate the right eye and a red light the left eye, for a short time there will be a mixing of the sensations, then one, let us say the red, will become predominant, then the green will be seen, then the red, then perhaps the combination of the two, then the red again, and again the green and so on. In a similar way it has been found that if one stimulus is given at a very short interval after another the second stimulus may be entirely overlooked. It is said to be inhibited. On the other hand, if the second stimulus appears at a later time while the first stimulus is still working we may have an inhibition of the first stimulus. If we become prepared to receive one form of stimulus and another form be given the given stimulus may not be appreciated, or as we say, may not be attended to. It is also found that if two stimuli of different intensities be presented simultaneously the more intensive stimulus will usually affect consciousness and the less intensive will often be unappreciated.

One element which produces or evaluates the attention is the motor adjustment. If the impression is sufficient to produce some motor adjustment to the stimulus it is said to hold the attention, and when two or more stimuli are given simultaneously only one of which requires a motor adjustment it is the latter which is attended to. The attention can not be said to be directed towards a special stimulus, but the stimulus is attended to if a motor response is to be given. Neither can the attention be said to be directed towards any special task for any length of time.

The wave is rising and falling and we have fluctuating attention all the time, necessitating new motor adjustments if we wish to attend to a thing. What is called attention directed over a long period of time is a constant repetition of attentive acts, a recurrence of the high part of the wave which in consciousness takes the illusory character of continuity.

Considering attention in a general way we may say, therefore, that it is an attitude towards certain presentations, which attitude is dependent largely upon the motor adjustments which must follow the stimuli. There are certain things at certain times to which we are unable to attend. This has been well described by James: "There are always some objects which for the time being will not develop. They simply go out, and to keep the mind upon anything related to them requires such incessantly renewed efforts that the most resolute will ere long gives out and lets its thoughts follow the more stimulating solicitations after it has withstood them for what length of time it can. There are topics known to every man from which he shies like a frightened horse, and which to get a glimpse of is to shun. . . . It is like 'memento mori' in the heyday of the pride of life. Nature rises at such suggestions and excludes them from the view: How long . . . can you now continue thinking of your tomb? In milder instances the difficulty is as great, especially when the brain is fagged. One snatches at any and every pretext, no matter how trivial or external, to escape from the odiousness of the matter in hand." What we call sustained attention is only possible when the presentation at each moment brings in new adjustments, when it leads to modes of reaction, and this is what we mean by the attention of the educated and by the education of the attention. If the object does not produce any special adjustment it is not attended to; if the mind does not hold things to which the present situation may be adjusted the present situation is not attended to.

Numerous tests have been made to determine the span of the attention, to try to discover whether or not it is possible to attend to more than one situation at the same time. Paulhan attempted to perform two dissimilar tasks at the same time[1] and found that he was able to do this if the tasks were easy. He also found that if he wrote poetry at the same time that he was quoting

[1] Cited from James.

other poetry or prose he performed the two operations (simultaneously?) in 40 seconds, if he performed the two operations successively he took 22 seconds for the recitation and 31 for the writing, a total of 53. This indicated that two operations might well be performed together, but on account of the lengthening of the time from 31 to 40 seconds, *i. e.*, the difference in time between the performance of the writing alone and that of the combined writing and recitation, we must assume that he was not attending to both operations simultaneously, but that in the performance of the two tasks there was a fluctuation of the attention from one to the other. The saving or the lessening of the combined times shows only that the attention may fluctuate from one task to another quite quickly, and that the performance of a combined task may take less than the combination of the times for each task. In such an experiment we have not attended to more than one thing at a time, but have attended to more than one thing in successive intervals of time.

When a stimulus has been presented and has been attended to it is taken in or is apprehended. The taking in may be of a gross nature, in the sense that the stimulus may leave only the general impression of blueness or of largeness, or it may leave a more definite impression when it has been elaborated further or when it becomes a perception or when it has been apperceived.

Apprehension is not a process like that of perception, although it is part of the latter, nor is it a condition like attention. It is part of all experiences of a sensory, perceptive, or apperceptive nature, and is a necessary part of these. It is the taking in of impressions, and is the first step in the process of assimilation or in the making of the situation a part of one's self.

Unlike attention we may apprehend many things at one time We are able to take in at a glance many objects, and although at the time we apprehend them we do not entirely assimilate them they are ready for assimilation or for apperception. Thus, we are able to take in at one time four or five digits or individual letters, even when we have seen them for only a hundredth part of a second. We can take in about fifteen letters when these letters are combined into known words. If the words be connected into phrases or into sentences we are able to take in about thirty letters at one glance. It will thus be appreciated that appre-

hension depends upon a number of different elements, not only upon the quantity of the elements which are presented. Stimuli which may be grouped into a whole or into two parts may be apprehended, even though the number of the individual elements be large, because the things are those which may be readily perceived or understood.

Perception or apperception is the taking in of a presented situation and making it part of one's mind. A sensation is an abstraction; as adults we are never conscious of sensations in themselves; we are conscious only of perceptions or of apperceptions. When we have any object presented to us we have the sensations of light and darkness, of color, of extent, and of shape; but we have a perception of an apple, or of a bell or of whatever it was that was presented. After the sensation is received, or after the stimulus is received there is a combination of the new impressions with mental relics (or memory images) of old ones, and the new impression is given a meaning. It is this giving of meaning to the sensation that we call perception or apperception, and this, as has been said, is brought about by the association or combination of the present sensory impulses with the relics of former experiences. All of our mental life is made up of perceptions and apperceptions and we never, after the first few weeks of infanthood, have to deal with pure sensations unless we be placed in situations utterly unlike those to which we have been accustomed, and even in these new surroundings we try to make perceptions form apperceptions.

The terms perception and apperception have sometimes been used synonymously.[2] The term apperception, as distinguished from perception, is to be used to indicate a greater complexity of associations. The term perception is used for the formation and combinations of a presented stimulus with the old, and the term apperception, of the combination of a presented complex situation with former ones, so that perception is commonly used to designate the condition of understanding of rather simple presentations and apperception for the appreciation of the rather complex ones. When we deal with simple objects, therefore, it is said that we perceive the object, and when we deal with a more com-

[2] In recent psychological literature, the term apperception is given a somewhat different meaning with which we need not deal here.

plex situation, it is said we apperceive it. If the terms be used in this way, we are not always able to distinguish between perception and apperception, and for our purposes they may be used almost synonymously.

In all mental processes a sensation is changed into a perception before a reaction takes place. When a sensation results directly in a movement, the whole process may be rightly considered to be a reflex, although a conscious perception follows the reflex movement. When the reaction does not follow the stimulus immediately, but only after there had been a taking in, or assimilation of the sensory element, the process on the receptive side is called a perception.

Sensations are exact; they are definite and depend less upon the individual make-up than does any other element of mind. If we except slight degrees of difference, we may say that the sensations obtained by each of us is the same, but our perceptions

FIG. 15. Fortification figure, illustrating effect of past experience in the interpretation of stimuli.

differ by as much as do our previous experiences. Figure 15 illustrates this. Here we have a figure, drawn in the form of an irregular crescent with jagged edges and composed of white and black lines. These are the sensations we get. If the observer has had certain previous experiences, he will interpret this figure to be a representation of the so-called "fortification figures" which are so commonly found associated with migraine. Here, it is the previous experiences that give meaning to the sensation, and whether we perceive the figure as a rather badly and irregularly formed crescent or as a "fortification figure" depends entirely upon our previous experiences. To most of us the writing of the Chinese is a collection of mere hen scratches, but to one who has studied the subject even in a superficial manner, the stimuli produce a definite perception result. The stimuli have

a meaning in the case of one and no meaning in the case of the other. One individual perceives the spoken German as the collection of growls or of guttural sounds, while another gives to the tones a definite meaning. He perceives them and he reacts in a way that is commonly said to be normal.

We may say, therefore, that perceptions and apperceptions differ as much as individuals differ in any other respect. This difference in perception leads to reactions which also differ and, accordingly, the individual activities are varied. The difference in previous education or mental content gives the character to most of our false perceptions (illusions and hallucinations). Delusions, which are also based upon sensations, and which often are only interpretations of certain sensational experiences, are also dependent upon the mental content.

At this point, it is appropriate to add a few words about delusions which, as has been said, are very closely allied to illusions and to false perceptions. The savage who calls upon the spirits when he is in pain and tries to pacify the devils in the air, acts in accordance with his previous perceptions; his present apperceptions and his actions are in perfect harmony with his environment and with his previous experience and education. So also the ignorant peasant who believes in witches, banshees or ghosts has these ideas and apperceives situations as a logical result of his past experiences. The interpretation (*i. e.*, perception or apperception) of present stimuli, whether these be abdominal pains or animal cries in the night, is consistent with the stimuli and with the mental make up. For this reason the investigation of the apperceptive ability of a patient is important.

Tests of perception and apperception ability may give information of the trend of the individual's mind and at the same time enable the physician to analyze some of the mental states which are too complex to permit of introspective analysis by the patient himself. On the other hand, these tests must not be considered methods of solving all mental problems, but only as assistants in this work. The interpretation of the results of these more complex tests is difficult, and at times definite deductions can not be drawn, but when considered in relation with other tests they are unusually instructive and valuable.

Attention

As will be judged from the discussion above, tests of attention are really tests of the ability to attend to impressions and not tests of attention itself. In laboratories these tests are commonly performed with stimuli at or near the threshold value and the results show that at times these stimuli are appreciated and at times they are not. For clinical purposes it is not possible to perform experiments with stimuli at or near the threshold value, and if the attention processes are not deranged to such an extent that they may be detected by much rougher tests they are not likely to be of great diagnostic importance.

The tests which are proposed here are of a very simple character. They are intended to indicate the presence of a variation in attention only in patients who at certain times are unable to bring certain objects or stimuli to the summit of the wave of consciousness. For example, in Korsakow's syndrome, there may be occurrences which are lost to the patient even though these occurrences have a value much greater than that at the threshold for normal people. In senility and in arteriosclerotic dementia similar states are found. In these conditions the attention disturbance may be shown occasionally by a failure to answer a question or by a break in an answer.

(*a*) *Qualitative Observations of Attention Ability.*—An estimation of the ability of the patient to attend to impressions may be gained by observations during the course of the ordinary mental examination. The experimenter must estimate the ability of the subject to take in what was said. Account should be taken of how often he is asked by the patient to repeat a question; whether there are periods of dreamlike or drowsy states; whether the subject appears to wake up with a start whenever a question is given, etc. Observations of this kind are much more valuable than the actual tests which are suggested below, for they indicate the attention ability during the periods of time when special emphasis is not placed on the stimuli and when there is no special interest in the test because of its novelty. It should be understood however that a request to repeat a question may not be due to defective attention, it may occur if the question be complex and the patient be unable to take it in or to retain all of its elements at one time. For this reason the examiner

must be very careful in the interpretation given to the phenomena.

(*b*) *Fluctuations of Attention with Simple Stimuli.*—A series of numerals or letters is read to the patient in a monotonous tone at the rate of one each half second and the subject is instructed to make a tap or other movement whenever a definite letter or digit is read, *e. g.*, 3, H, or R. Since the digits are arranged in an irregular order the subject is not aware when the digit "three" is to be said and an accurate apprehension and reaction to these stimuli require fairly close and sustained attention. If the subject is unable to attend he will at times fail to make the appropriate responses when the word "three" is said. In this way, we may determine any rhythmicity in the lowering of the attention or a failure to take in one or more of the stimuli. The following examples are given in the first two of which the digit three is taken as the stimulus, and the letters R and H respectively in the third and fourth test.

(3) 4 3 1 8 5 9 6 3 4 6 5 1 4 7 6 4 8 6 7 2 3 6 2 4 7
3 6 3 6 7 6 3 9 3 1 6 7 3 6 9 3 5 6 4 8 8 2 3 1 5
8 6 1 4 6 3 9 4 6 7 9 7 8 1 6 8 3 9 8 6 3 9 4 2 3
1 3 2 8 6 9 8 3 6 9 7 1 8 6 7 6 4 3 8 5 3 3 5 2 7
7 9 2 6 5 1 2 8 6 2 8 7 6 9 6 4 3 7 2 8 1 7 3 1 8
1 7 3 6 9 2 7 5 3 4 3 8 4 1 6 9 2 5 4 6 9 8 7 3 2

(3) 4 8 9 3 2 7 6 8 3 5 4 9 3 1 5 3 2 7 9 4 8 1 3 5 7
6 2 1 9 3 1 4 9 7 3 1 6 2 5 2 3 8 3 3 6 7 3 2 9 3
5 7 6 8 5 3 4 2 9 3 7 1 6 7 9 4 3 9 3 6 5 8 1 3 4
7 5 6 3 6 1 8 5 3 2 9 3 4 8 6 3 7 1 8 4 3 5 4 7 9
1 3 6 2 1 3 7 5 3 4 8 6 9 5 3 5 2 6 4 5 8 6 2 4 6

(R) P O O S G O O L S A O S L S D D G O G L P L A L G
D A L A O G G D D A O A R G A D R R L G S L O O A
R D G A P R P G O L D R A P R P S A G S S A O A P
G L S L L O D S D O P L G P D A G R G A A S G S P
A O L L D L P S P D R A O P D G S P R A R A P L A
S P L R L R D G O P R A P S D R S O R A D L R S L
S R G R P S P G S R O G S R R G O L D S P P D O R
D S D O P D O O D A P R L O P G A L G D S L R D G

(H) T N N Y H N N I Y B N Y I Y C C H N H I T I B I H
C B I B N H H C C B N B W H B C W W I H Y I N N B
W C H B T W T H N I C W B T W T Y B H Y Y B N B T
H I Y I I N C Y C N T I H T C B H W H B B Y H Y T
B N I I C I T Y T C W B N T C H Y T W B W B T I B
Y T I W I W C H N T W B T Y C W Y N W B C I W Y I
Y W H W T Y T H Y W N H Y W W H N I C Y T T C N W
C Y C N T C N N C B T W I N T H B I H C Y I W C H

(*c*) *Fluctuations of Attention with Complex Stimuli.*—A similar test may be made by having the patient report whenever a particular word in a story is mentioned. This is a test similar to the old parlor game in which the subject is required to make a reaction when definite words are mentioned. For example, the experimenter reads a story to the subject who is instructed to react (by tapping or by repeating the word) whenever he hears a certain word. Suppose the word "barn" should be chosen for this purpose. The subject is instructed to clap his hands or to repeat this word whenever it is given in the story. The following story is then read:

"When a boy, on every possible opportunity I went to the *barn* in which there were not only various implements used about the farm but a variety of old tools and machinery which had been stored there for many years. The *barn* was high and had three stories which originally were used for many purposes. It had been built fifty years before I was born. The old inhabitants said that when it was built the *barn* was the best known in the country and, although other *barns* of greater size and of more ornate appearance had been erected in more recent years, they still continued to talk of it as one of the most wonderful buildings in existence. The building had been used for other purposes than that of a *barn*. It contained a wonderful collection of tools of all kinds, and several neat workshops that were well stocked with woods of all kinds. Adjoining it was a *barn*yard, laid out at a later date, but with small houses for the chickens and ducks which were miniatures of the large *barn* building, etc."

(*d*) *Attention in the Performance of Simple Acts.*—Have the patient tap with a pencil between the lines of ruled paper moving to and fro as rapidly as possible for a period of thirty seconds. At the end of each line note the time which has elapsed. A comparison of the number of taps with the time may show that at certain periods the patient has reduced his speed and has tapped much more slowly than at others. The element of "speeding up" which comes during the first five seconds of such a test must be kept in mind, and also the "fatigue" effect which comes during the latter half of the test. During the first five seconds there is usually found with normal people a gradual increase in speed, which must not be taken as evidence of lack of attention at the

beginning of the test. A gradual slowing in speed after the latter part of the test, on the other hand, can not be considered to be evidence of a waning of the attention, for this is a normal phenomenon due to the wearing out of the nervous structures. Fluctuations, *i. e.,* alterations of high and low speeds, are, however, indicative of waning and waxing of the attention process.

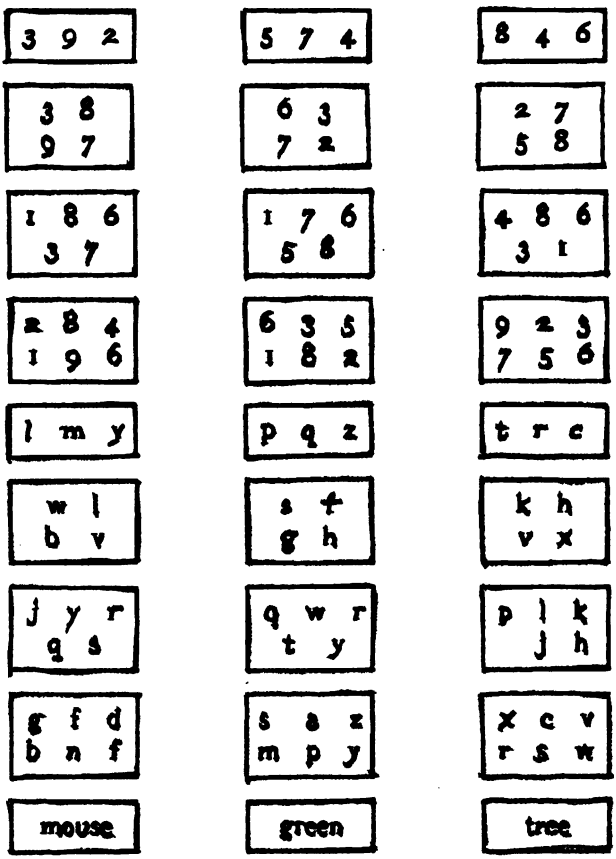
(*e*) *Attention in the Performance of Accurate Movements.*— A similar experiment may be made with cross section paper (2 or 4 squares to the inch). The subject is instructed to tap in each square as rapidly as possible, going to and fro. The experimenter notes the time for the taps along the particular lines. In this way the test may be made for 300 squares and if the cross section paper contains 20 squares to the line it will be easy to determine directly the fluctuations in speed for successive 20 movements. It will be seen that this test is somewhat similar to one which has been described in the section dealing with the accuracy of movement (p. 46) and to another in the chapter on the time of mental processes (p. 128). In this test, however, there should be a mean of stress placed upon accuracy and upon speed. Not so much emphasis should be placed upon the accuracy as in the test on the time of mental processes, and not so much stress placed upon the speed as in the test on the accuracy of movement. In the interpretations of the results of this experiment the considerations mentioned in connection with the preceding experiment are to be kept in mind, viz., there may be a "warming up" period with an increase in speed and a "fatigue" period with a lessening of the speed which are normal phenomena.

Apprehension

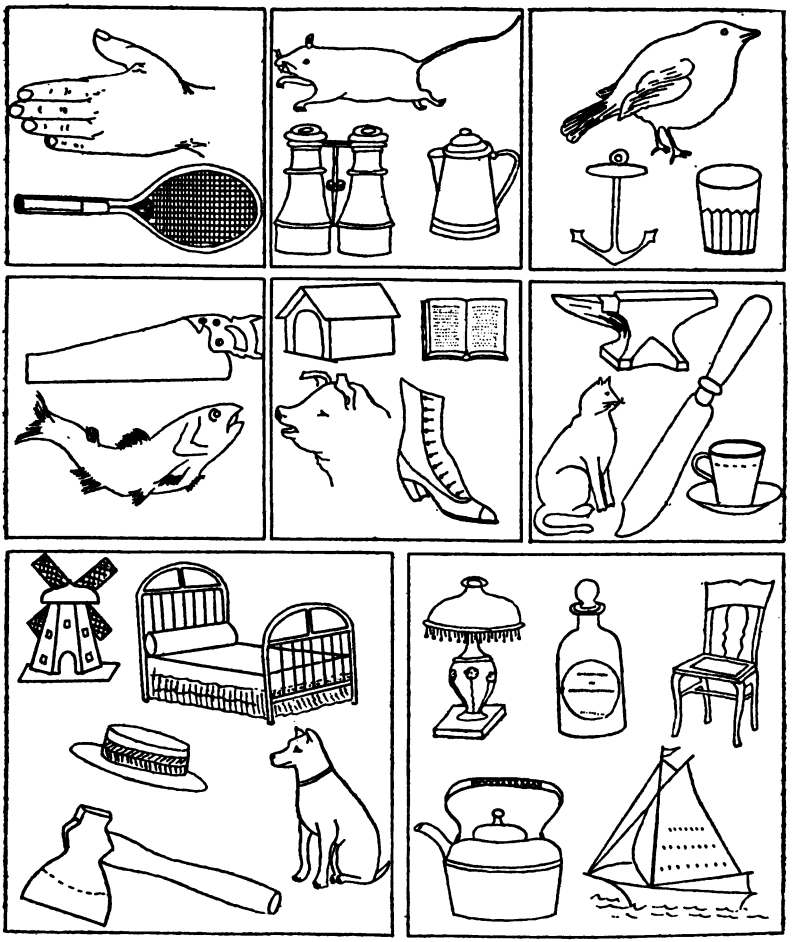
Apprehension depends upon attention, and the reactions of a subject which lead to deductions regarding this ability to take in stimuli also depend upon the ability to retain and to reproduce the stimuli. For these reasons apprehension tests are at the same time tests of memory and of attention. Special care must be taken, therefore, in the interpretation of the results of these tests. If the subject is unable to reproduce at one time a series of six disconnected digits or letters which have been shown, this inability may be due to a failure to take them in (apprehension) or to a failure to retain them (memory) or to a failure to attend to them.

With careful testing it is sometimes possible to differentiate the part each of these processes plays in a dementia, although the tests which will accomplish this are too elaborate for clinical or ward purposes.

(*a*) *Apprehension Test.*—Show to the subject for about 0.2 second a few digits or letters and have him report what was seen. The exposure may be made by placing on the table in front of the subject the card containing the digits or letters which are covered with a sheet of paper, which latter is drawn away from the digits or letters and replaced as rapidly as possible. Cards bearing the following or similar combinations should be prepared and used in this test:



dog house	cat grass	horse wagon
bush water bug	mule bottle cow	vine rubber rope



Apperception

Tests of apperception ability must necessarily be complex and the test sometimes gives indication not of the ability of apperception but of the apperception mass or the mental content of the subject. For example, in a test in which the subject is to interpret certain stimuli it will be appreciated that the way in which these are interpreted will depend upon the previous experience of the subject and that the perception and the report of the meaning can be taken only as an indication of the ability of the subject to make a comparison with his previous experience.

When stimuli are presented which are like other previous ones which had meaning for the subject he often reads into the stimuli meaning which should not be attached to them. This is done, however, because the stimuli have certain characteristics like other familiar stimuli the meaning of which the subject knows. For example, the word "hosqital" if shown to a patient for 0.1 second is often read "hospital." So also diagrams, monograms and complex pictures are interpreted by the subject in

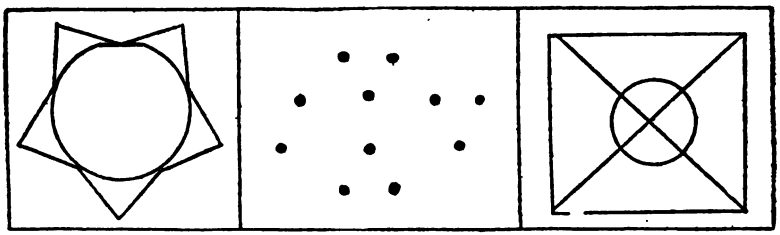


Fig. 16. To illustrate false apprehension and perception.

accordance with his interests and previous experiences, although often the subject misinterprets these or apperceives them in a wrong manner. The accompanying figure (Fig. 16) illustrates some of these. The first of these is usually perceived as a "regular five-pointed star with a circle inside," the second is reported to be "twelve dots grouped in threes," and the third is often said to be "a square with diagonal lines and a circle in the center." Usually the subject reports a something like the picture which is shown but he varies in his report to make the picture come in line with his previous experiences.

Probably this function is never so deranged that after stimuli are consciously taken in they can not be perceived or apperceived.

We do find, however, that when they have been taken in and lead to reactions, the appropriateness of the reaction and, consequently, the perception and apperception may be different according to the individual. By having a complex test such as that of the stories (see test *f* in chapter on memory, page 100) we are able to judge of the ability of the individual to perceive and apperceive situations which are presented to him. On the other hand, reports of the contents of these stories may not show any abnormal traits or the reports may be so meager that one is unable to judge whether apprehension or apperception or memory has been affected. In addition to the information which has been gained throughout the general examination of the subject certain comparatively simple tests may be performed. These are not simple in themselves but simple in relation to the testing of this particular function. Here also care must be exercised in the interpretation of results, for the complexity of mental elements involved in the test will never warrant a snapshot judgment.

(*a*) *Ebbinghaus Test.*—The subject is presented with a sheet of paper on which one of the following stories has been printed and in which the words here shown in parentheses have been omitted and replaced by blank lines. He is instructed to read the disconnected story carefully at least once so that he obtains a general idea of it, and then to fill in the blank spaces with words appropriate to the story as a whole. He should be advised not to write or report a word for a particular space until he is satisfied it fits there. The following stories are suggested, the appropriateness of the individual stories to the subject being a matter which must be settled by the experimenter in accordance with his knowledge of the subject's life and interests. If the subject uses words different from those shown in parentheses they should be considered correct if they make the whole paragraph sensible and consistent, but should be judged to be wrong if the paragraph as a whole is not sensible, even though the separate sentences be correct in themselves:

1. Once upon a time a (donkey) heard a (grasshopper) chirruping in the (grass). Ah, he said to himself, if I could (sing) like that, how (happy) I should be. So he bowed low to the (grasshopper) and said, kind friend, what (food) do you eat to make your (voice) so sweet? I (drink) the evening dew, re-

plied the (grasshopper). The foolish (donkey) tried to live on the same kind of (food) and died of (hunger).

2. Monkeys are (playful) and (amiable) creatures when (young), but become (quarrelsome) and (dangerous) as they grow (older), especially the males. They pass most of their time in alternate (peace) and (fighting). After a violent (quarrel) they change to the other extreme, and behave as if they were the most (gentle) of creatures. Animals at one moment living in perfect (harmony) and (peace) become in an instant deadly (enemies), ready to (tear) each other to (pieces).

3. During the early centuries of Christian Spain the conditions of the (country) were such that every (king) was obliged to defend his (right) to the throne against the (rest) of his family, so that almost constant (wars) were being waged among the nearest (kin) and it was practically impossible that several (kings) of weak and incompetent (natures) should not have been wrested from the throne.

4. Penmanship as an art is doomed if the most advanced school (authorities) have their way. The (typewriter) will usurp the place of the (pen) and the (pencil), but the innovation will be (advantageous) in that it will (produce) better spelling and at the same time it will prove of ethical (value) since it will no longer be necessary to waste (minutes) and (hours) on the (scrawls) which now beset us and which at times cause much (profane) language.

5. The (stock) market was very (irregular) the past week, and sales were very (light). The (reports) of various railroads have affected the (quotations) and in some (cases) rumors regarding possible action by the Interstate Commerce Commission have helped to make the market (unsteady).

6. The most (important) elements in house-keeping are absolute (cleanliness) and (regularity). The (servant) who is unable to acquire these habits will always find her (work) difficult and (irksome) and she will always receive (criticism) and (rebuke), and be unsatisfied with her (work), her (position) and her (social) life. If, however, these (habits) are acquired, the work becomes (easy), and her (services) are appreciated.

7. A boy once thrust his (hand) into a pitcher filled with nuts. He grasped as many as his (hand) could possibly (hold);

but when he tried to draw out his closed (fist), the narrowness of the (neck) prevented him from doing so. Unwilling to lose his (nuts), yet unable to get them by drawing out his (hand), he burst into (tears) and bitterly lamented his (hard) fortune.

(*b*) *Heilbronner Test.*—This test is one which is to determine how well a subject may grasp the meaning of pictures without the completion of the pictures, or, in other words, how much the subject may be able to read into or apperceive simple stimuli. In this test series of illustrations of simple objects are made, the illustrations in a series ranging from the very simple outlines of principal parts of an object to the completed rather complex picture. A glance at the illustrations, Figs. 17, 18 and 19, will indicate what is meant. For example, in the series of the watch, there are at first three concentric circles to which is added in the second picture an obtuse angle placed at the center of the circles. In the third illustration twelve marks are made within the innermost circle and the angle has been elaborated. Further elaborations are shown in the other illustrations of the series. The first picture may be taken to mean almost nothing, the second gives an indication of what the completed whole may be and in the fourth of the series the doubt whether the illustration is that of a watch or a clock is set at rest by the appearance of the circle for the second hand. Similarly with the pictures of the fireplace, graphophone, etc. The first illustrations do not always clearly show what the finished picture will represent, but the successive elaborations make this plain.

The object of the test is to determine what amount of detail must be presented to the individual so that the picture be apperceived in the way in which it should be. Heilbronner adds to this the requirement that the subject be asked to specify the differences between the individual pictures, but this is not a very satisfactory procedure with the mentally abnormal. This test has been used for the determination of apperception ability in children, and in any series it has been found that children are usually able to designate the name of the object after two or three of the illustrations have been shown.

In the performance of the test the first illustration of a series should be shown to the subject, who is told that this illustrates in a general way some of the principal outlines of an object which

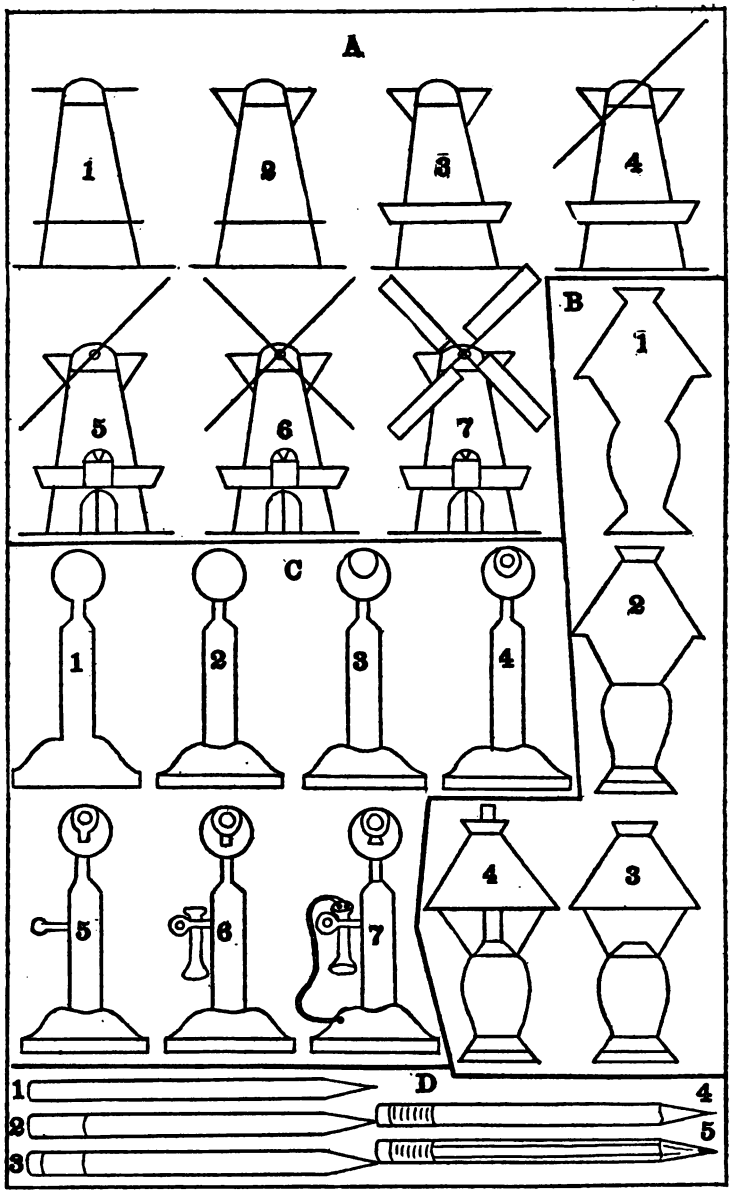


FIG. 17. Figures for the Heilbronner test. *A*, windmill; *B*, lamp; *C*, telephone; *D*, pencil.

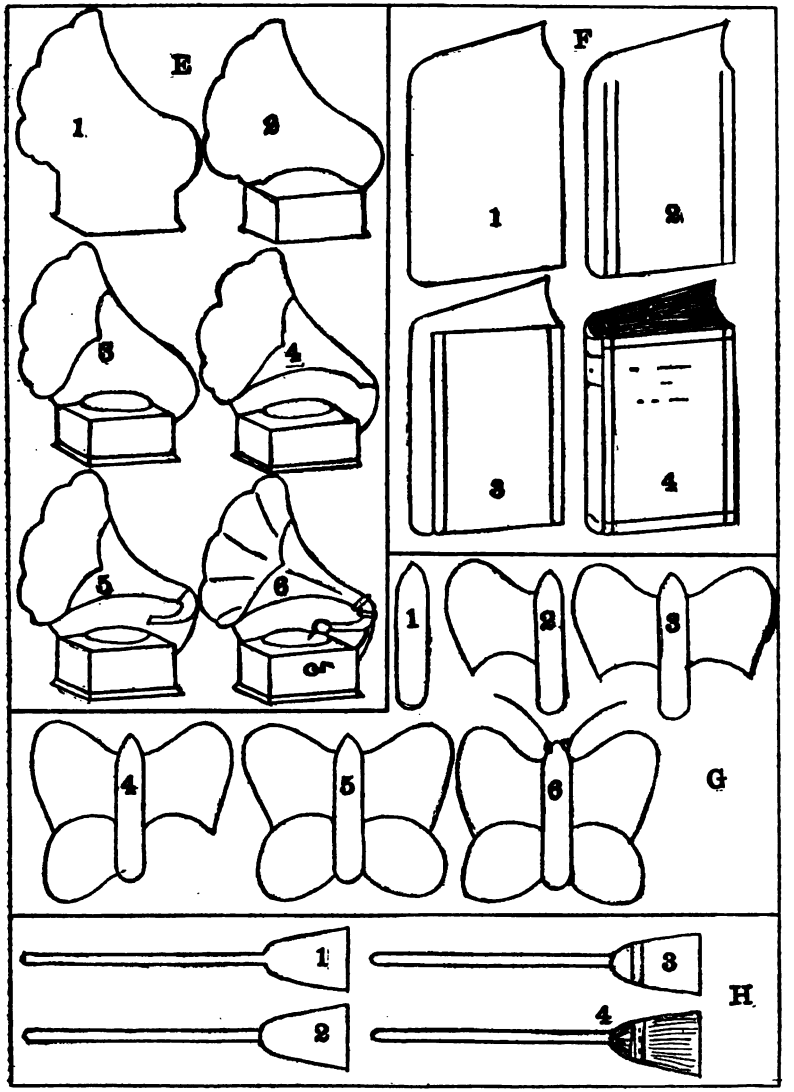


FIG. 18. Figures for the Heilbronner test. *E*, graphophone; *F*, book; *G*, butterfly; *H*, broom.

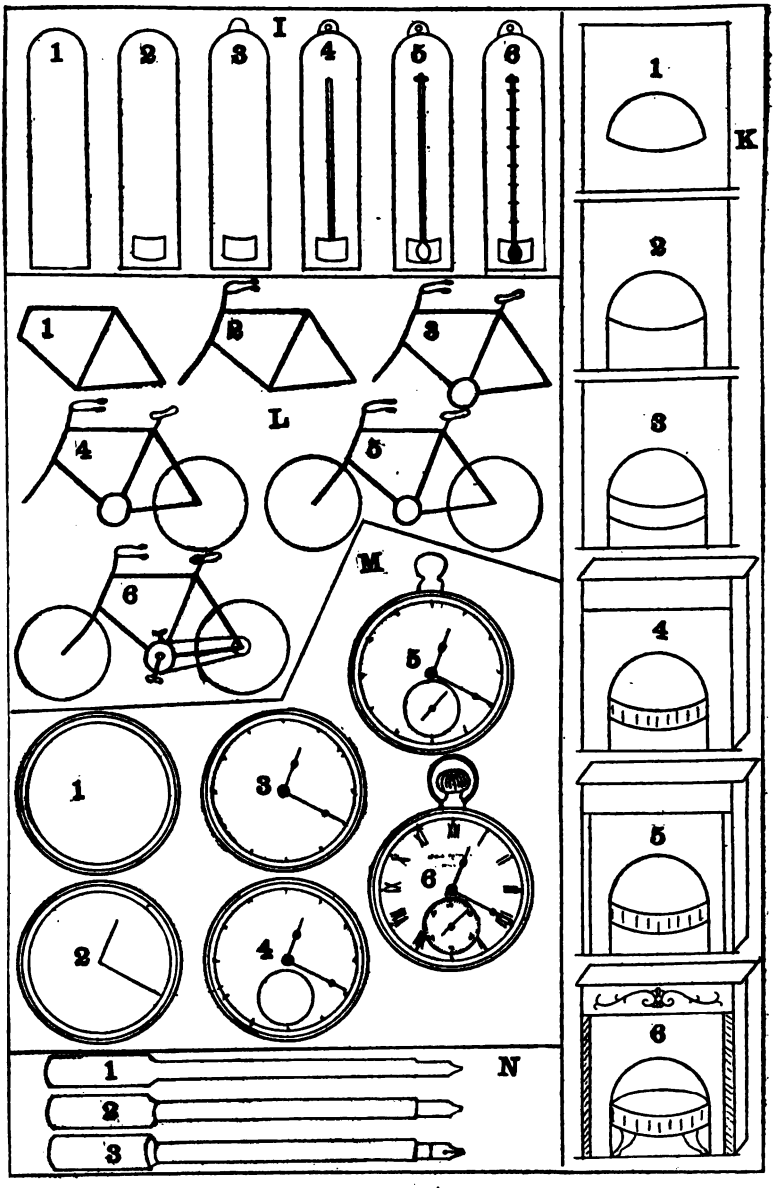


FIG. 19. Figures for the Heilbronner test. *I*, thermometer; *K*, fireplace; *L*, bicycle; *M*, watch; *N*, fountain pen.

is familiar to him. He is asked to tell what the object is, or, if he can not do this, to describe the picture in brief terms. This illustration is then turned over and the second of the series is shown. If he does not identify the picture, have him tell what difference there is between the present one (after it has been covered) and the previous one. The other illustrations in the series should be shown successively, each time asking "What is it?" and "How does this differ from the preceding one?" It is advisable to get the subject *en rapport* with the experiment by showing two or three of the series and for this purpose I have usually selected the butterfly, the lamp and the fountain pen.

At times the subject may report a name different from that given here, but if it include the main points it should be counted correct. For example, the graphophone is sometimes called a phonograph; the wind mill, a mill; a lead pencil, a pencil; the fountain pen, a pen; the fireplace, a mantel, etc. The following should not be counted correct: clock instead of watch; spade instead of broom; pump instead of telephone; light instead of lamp; etc., although it must be admitted the illustrations do suggest in some particulars the names which are considered incorrect.

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See also references 2, 8, 11, 17, 19 (Chap. I) and 120 (Chap. IX).

CHAPTER VI

MEMORY

In the mental examination of patients memory tests hold the same or an analogous position as does the testing of the reflexes in the examination from a neurological standpoint. Usually, we depend upon the memory of the individual in all its aspects to give us information regarding the present mental state with which we have to deal. It is necessary, therefore, to acquire information regarding the memory of the individual before we are able rightly to form a judgment regarding such mental things as attention, apperception and the like. It is necessary to test the individual in a general way and determine the condition of memory before we can rightly conclude regarding special tests of other mental processes or elements. In certain tests of apperception this fact becomes obtrusive; in the Masselon test, for example, we may not give five words to a patient for the purpose of forming a sentence and draw correct conclusions in regard to this ability unless we know that he is able to keep in mind five words at one time. In other words, we must presuppose the presence of a certain amount of memory and we must know about the character of that memory before we should attempt to test the individual for many of the other special processes.

Moreover, for the purpose of limiting the diagnosis it is always necessary to know whether the memory is good or poor, and also to know whether it is better for recent or for remote events. The feeling of the patient in regard to his memory ability is known to be an unsafe guide or indication of the real condition, but these feelings and supposed deficiencies in memory ability must be considered. At times they are almost as instructive as the real memory weaknesses.

For the proper understanding of mental failures and deteriorations it it necessary for us to have for each case as clear and as accurate a conception of the character and the amount as well as the temporal aspects of the memory losses and imperfections as we can obtain. From present diagnostic and prognostic view-

points it may, perhaps, be unnecessary to know more than the bare facts of the occurrence of memory gaps and faults. It may be sufficient to know that the individual has a "leaky" mind, in which sensations and other events are not retained. Advance in both prognosis and in diagnosis is only possible, however, when the cases are more thoroughly examined and when we shall study what the memory losses mean in individual cases or in collections of cases.

For the proper understanding of the disturbances of memory in mental diseases it is necessary to keep in mind the conditions affecting memory in normal individuals. At the same time it is essential to remember that there are different kinds of memories in both normal and abnormal people. If, for example, you close your eyes and think about the appearance of your room you may have a mental picture; and in this picture you see the different parts of the room clearly or dully, you may be able to note the individual elements on the walls, the particular parts of the table or of the chair, or you may have only a very vague picture of the elements and be able only to picture the room in a rather indefinite fashion. In whatever way the room is pictured by you, no matter in how little the picture you have resembles the actuality, you have had a memory image. The memory image of which I have been speaking is a visual image, but if you try to recall the taste or the smell of an orange or of a cheese sandwich, you may have an image with gustatory or olfactory elements. If you try to recall the tone of a violin or of any other musical instrument you may have a memory image of an auditory character. In all remembering we have these memory images, the kind of images depending upon the sense qualities we try to recall. Galton, who was the first to investigate the matter with any degree of thoroughness, found that the memory images for the different sense fields differed in different individuals; that some subjects were unable to recall images other than visual and that only a few were able to recall images dealing with the qualities of taste and smell.

Even in individuals who are of the same class—let us say, visual minded—we find differences in the facility with which certain things of the same nature may be recalled. The broker who deals in stocks and bonds and the butcher who deals in meats may both be visually minded, but each has memory images for

only certain things. The former may be able to recall the prices and the fluctuations of stocks of a certain class over long periods of time and the latter may not know the price of one stock but may be able to recall accurately the varying prices of meat. In the latter cases the memory images do not so much depend upon the sensory quality, but upon a factor which is of as great importance, viz., interest or attention.

It will be seen that memory includes both the retention of a past experience (sensation or other event) in the mind, and the ability to bring back this relic into the field of consciousness. The ability of recall may be shown by the reproduction, by the making of a new thing like the old (as for example, by speech) or by the selection or identification of the present experience as the equivalent of the past. Furthermore, it is important to bear in mind that recall in its various forms (selection and reproduction) with retention do not constitute memory from a psychological point of view. In addition to these two factors we must have the feeling that the sensation or the event-complex, which is retained and recalled, has happened in time past.

Although the retention and the recall are intimately related we must not forget that they may be distinct. The recall can not be present without retention, but even a casual consideration of the subject is sufficient to indicate that the retention may be present without any ability of recall, or, to limit the statement and to make it more exact, we may say the impression may have been retained without any ability of voluntary recall or of recall at will. The retention of the individual may be almost perfect for any given event or occurrence or sensational experience, as shown by the accuracy and the kind of reactions which take place and which depend upon the retention of the past experiences, and at the same time the individual may have the ability of recall at a minimum or even at zero. I may react to a given stimulus or to a collection of sensations or to a situation; my reaction may be of the sort which shows clearly that I have had a similar stimulus or have been in a similar situation at some previous time, but if I can not recall that there had been a previous similar experience, from the mental standpoint no memory of the event can be said to exist. An example of this sort of retention, without memory, is that found in the condition of post-hypnotic suggestion. The

impression (*i. e.*, the commands) given during the state of hypnosis is retained, the individual reacts in a manner which clearly shows that there has been a retention, viz., the previous sensations have been stored up in the mind, but except he be again hypnotized the patient does not recall the giving of the suggestions or the commands. In his normal waking state he can usually offer no explanation for the act he has performed, even though the affair appear to him to be bizarre, or perplexing or even opposed to his usual mental make-up. He has no memory of the suggestions which were given to him, nor can he remember who gave the suggestions. The subject has undoubtedly retained the sensations and has been able to make the appropriate reactions to the stored-up images or ideas, but for the period of time in which he was under the influence of the hypnotizer he has what we all agree may be called an amnesia, or a memory loss.

So far, then, we may say that there are two essential elements in memory, retention and recall. Some would limit the term memory to this form of mental process, to the having of an experience and to the recall of that experience. The conception of recall has even a broader signification for some. If a new stimulus causes a reaction similar to that produced by a former one, if the new situation is reacted to in a way which indicates that the past experience has left traces this condition has been called by some an organic memory. It is difficult to picture or to conceive what is exactly meant by organic memory, but it appears to be something like that which happens in a steam engine, or in some other piece of mechanism. At first, be it never so exactly fitted, there is something lacking in smoothness, but after the machine has been put to the same use a number of times, even the second time, it runs more smoothly. It has what we may be justified in calling an organic memory. Memory in man means, however, more than the retention of the effect of a past experience and an ease in dealing with a new stimulus like the old.

An example may help to bring this fact out clearly. The example is a comparison of the actions of an animal and of a man under approximately similar conditions, and of the interpretation of these actions. The story goes that a sportsman took his dog with him on a shooting trip. This particular dog was not fond of cats and gave the latter much trouble by chasing them when-

ever he saw them. As the dog and the man were walking along the road the dog saw a cat and immediately gave chase. The hunter could not hold the dog and after walking some distance found him at the foot of a tree, into which the cat had taken refuge. After much barking and ineffectual attempts to go up the tree the dog was finally dragged away, and was taken home by another road. A week or two later the same hunter and the same dog travelled the same road and when the dog approached the tree up which the cat had disappeared some days before, he immediately began to bark and tried to ascend the tree. It is usual in such a case to say that the dog remembered the previous situation, that he remembered the cat had been in the tree, etc. That there is something lacking in this situation which would justify the conclusion that the dog remembered will be evident from the way in which we would consider similar actions of a man under similar circumstances. Suppose now the hunter had been keen on cats. Going along the road he saw a cat, which he finally treed. On account of the thick foliage, however, he was unable to locate the cat but took a chance and fired off his gun into the mass of leaves. Nothing happened and the disappointed hunter finally went home by another road. A week or two later he happened to go by the same road, saw the same tree, but did not see the cat, and discharged his shotgun into the tree as he had done the first time. What interpretations are to be made of the act of the man? In the first place we may consider what mental processes both the man and the dog had. It is apparent that both retained from the previous experience some sort of memory image of the tree and of the situation as a whole. It is also apparent that the sight of the tree (a particular perception or sensation) caused a reaction, which could only have been performed because of the previous experience. There was in both cases retention. In both cases there was identification of the present with the past. In both cases the reaction which resulted was an appropriate reaction to the original experience. But, what was lacking in both cases, the absence of which causes us to conclude that the man had no memory or had lost his memory, is the element of feeling that the present situation is like one which was encountered in past time. Neither the man nor the dog posited the cat-experience in past time, and by this lack they

showed evidence of lack of memory in the true psychological sense.

Memory depends upon a number of factors connected with the experiences. The things remembered are usually remembered because of certain relations with the present. The present perception in its formation has depended upon the stimulation of certain, unknown, brain elements which stimulation has somehow, also unknown, brought up memory images of experiences from the past which have possibly acted upon the same or neighboring brain elements. It is supposed that the stimulation of the same or of neighboring cerebral elements produces the general feeling of sameness, or the feeling of identity or of the vaguer feeling of similarity. We know psychologically that these feelings become prominent after certain stimuli, but we do not know physiologically what actions of the nervous system correspond with these feelings. We also know psychologically that the present is linked with the past perceptions and apperceptions, but of the physiological and anatomical relations of these we are ignorant.

The present will be remembered because of certain elements contained in the stimulus or because of certain physiologically unknown, but psychologically described, conditions of the nervous system. Three conditions affect the memory of a past experience: recency, the frequency and the vividness.

It is well known that an experience of an hour past may be remembered with a fair degree of accuracy, the details may be clear, both in regard to the thing itself and in regard to its relations. On the other hand, as time goes on the details become less clear, there is a gradual blurring or haziness about the occurrence and finally the thing disappears and is no longer brought to mind. There may still remain a trace of the past experience which may have a mental effect but which is not remembered (or recalled) for not infrequently we find new impressions give rise to the feeling of familiarity, which in its emphasized state has been described as the feelings of "déjà vue" and "déjà entendue."

The more often one has an experience the more easily may that experience be brought to mind. We remember those things which recur, even though they have not the special character of rhythmicity. The occurrences of the same kind which come often appear to leave a cumulative effect on the mind, and both

recognition and recall are more easily brought about. On the other hand, some rhythmically occurring experiences are not recalled, they leave no memory impress because they become almost automatic. We can not, for example, recall the number of steps we took between different buildings, we can not recall the number of bites we made at a meal. It is true these are automatic processes, but they depend upon the receiving of similar impressions, many in a day and one succeeding another. In a general way, however, we remember those things which happen time and time again. A long series of words, a long series of numerals can not be recalled after one reading, but when the series has been many times repeated it may be retained for long periods of time and may be readily recalled. Those things which have connection may more easily be remembered than those which have no connection. A series of twelve disconnected words read once are approximately the limit of normal memory, but twelve words connected into a sensible sentence may easily be retained and reproduced.

The vividness of the impression has much greater effect than most other factors. The stimuli which have great intensity are remembered better than those which are near the threshold value, but vividness implies more than mere intensity in the stimulus. It implies a mental attitude on the part of the perceiver. Occurrences of an emotional nature have a vividness which those of an unemotional nature do not have. Presentations, therefore, which cause widespread bodily reactions at the time of stimulation are most easily recalled. The ordinary routine occurrences of the day have little or no emotional value and are soon forgotten, and often we find that not only can they not be voluntarily recalled but they are not even recognized when another wishes to recall them. On the other hand, the situation which is attended by an emotional response is remembered, it is not only easy to recognize it, but it is to recall it. It is for this reason very largely that the broker is able to recall the prices of stocks. They are facts or occurrences or stimuli which have an emotional value for him, or as we say, an interest. Here we must note that the general state of mind of the brain is of importance. If we are tired, impressions have not as great an effect upon us as they do when we have had a refreshing sleep. Fatigue reduces

the interest or the emotional value of the experience, and what at one time would have sufficient effect to be remembered may pass out of mind in a very short time.

Throughout the discussion so far certain conditions have been presupposed. It is supposed that the individual has given attention to the impressions, it has been supposed that he has taken them in, or has apprehended them, and it is supposed that he has perceived the stimulus or has apperceived the situation. These factors are most important for retention and for recall. If a stimulus be given and it is not attended to, it is unusual to find that it is remembered. We pass before a shop window, we see a multitude of things, but usually can recall neither the things nor their positions. We can at times, however, by means of after-images or of memory pictures call up the general appearance of some particular thing which at the time has not appeared to attract the attention. It appears, therefore, that in our estimation of memory we must deal with the factors of attention, of apperception and of interest upon which the other two depend. There are some abnormal cases to which these remarks may not apply, although our information regarding the mental processes in such cases is very meager. I refer to the abnormal feats of memory in imbeciles. Here we apparently find no special attention or interest, and all their other mental processes do not indicate the presence of much ability of apprehension and of apperception. Yet we find that such individuals may retain long series of disconnected words or figures, as well as of connected or related material.

Since the memory depends upon so many different factors, of interest or of emotion, of attention, of apperception, and the like, and since we find individuals differ a great deal in the kind of material which can be remembered, the testing of memory of any individual is not as simple a matter as is commonly believed. In our estimations of memory ability we rely upon the information which we acquire in two ways, one in which the general activities of the individual are taken as a basis for our judgment, and the other in which the special abilities of the individual are tested. Under the first come all tests or questions having to do with the daily life, habits, etc., and under the second come the special tests which have been devised and which are in almost common use. These we need to consider in some detail.

Tests of Memory

In the testing of memory the factors which have been mentioned in the preceding discussion must be kept in mind and, furthermore, special attention must be given to several of these factors because of the importance which they have in the determination of the mental ability of the individual subject. It is usual in making tests of memory for ordinary clinical purposes to rely upon the tests of the retentiveness and ability of reproduction of impressions which have been gained through the medium of the sense of hearing. It will be appreciated that the results of tests of this character will in normal individuals show decided variations and these variations are at times so extensive as to lead one unacquainted with the subject to conclude that certain of these individuals may have a pathologically faulty memory. On the other hand, individuals, who have a relative inability to remember those things which are heard, often have an extraordinary memory for those things which are seen. It is necessary therefore in the testing of memory that we should test it in a number of ways, and not rely upon the individual tests in one particular sense field. The ability to reproduce a given series of impressions will depend upon the value of the particular kind of sensory impression to the individual. It is commonly said that we are largely a visual people, but we must not assume that each one is visually minded, but, on the other hand, we must be sure that the tests are applicable to the individual.

(*a*) *Qualitative Tests of Memory.*—The general observation of a subject will give some indication of the gross memory or memory changes of a patient. If the subject happens to be a hospital patient, observation of his ability to find his room, to find the dining room and other special places may give clear indication of memory faults. In addition, general questioning of the patient regarding his life will also indicate any marked deviation from the normal. Answers to questions regarding name, age, date of birth, birthplace, and the like give evidence of the state of memory but these questions may be answered correctly even with very extensive memory defects. Many of these questions are of such a character that they require for answering only a certain amount of associative ability and not a memory ability in the proper sense of the term. When the name is asked, the name

may be given correctly, but this answer may be of a nature of a reflex, the mental process being practically nil, and all that may be discovered by such a question is the almost reflex ability of the vocal cords, of the respiratory apparatus, and of the muscles of the mouth and tongue, and the preservation of the nervous reflex mechanism. This is very similar to the reaction of a patient (*e. g.*, in a delirium) who is unable to answer other kinds of simple questions but who shows a reflex response whenever his name is called. Similarly, with questions regarding residence and even regarding age, these questions may be answered perfectly and yet show nothing in regard to the memory ability. Questions regarding one's occupation and the names of members of the family and other similar information may also elicit proper responses without having touched upon a mental state or process which requires any form of memory other than that of the ability to react in a definite manner after a given stimulus has been received. It is therefore necessary in the estimation of the memory ability of a particular individual to take special account of those occurrences with which he is well acquainted, but to which he has responded a great number of times.

Keeping in mind what has just been said of the conclusions to be drawn from answers to certain types of questions, the examiner should, with his knowledge of the individual from the history supplied from the family or friends, frame his questions to bring out the ability of retention and recall. In regard to occupation, for example, memory tests may be made by asking for details of the dates and kinds of occupations which he has had. Similarly, questions in regard to residence, if he has moved from place to place, the names of firms, etc., the ages of his children, the occupations of his relations, etc., will give information of the ability to recall over a long period of time.

In clinical work it is also necessary that a distinction be made between memories of remote and of recent events. It is well known that many subjects are able to recall recent events quite readily, but remote events are recalled poorly, if at all. On the other hand, there are some who recall their childhood days and can give details of occurrences of 50 years ago, but who can not recall the occurrences of the past hour. For this reason, separate questions are given to determine recent memory, and memory

for remote events. If, at the examination, the physician introduces himself to the subject on the latter's entrance and makes certain that the name is properly understood, the ability of retention and recall of this may be tested in five or ten minutes. Of a hospital patient one may ask details of when and how he was brought to the institution; one may ask what was eaten for breakfast or for dinner the day before, and recent journeys or occurrences which have been reported by the family may be inquired into. The information which is acquired in this way of the state of the memory of the individual gives in a rough way whether the memory be good or poor. It does not tell how good or how poor the memory may be, and to determine this special tests are necessary.

(*b*) *The Span of Memory.*—The simplest test for memory span is to present to the subject a series of individual digits, letters, words, and words in sentences and to have these reproduced by the subject immediately after they have been given. It is usual to perform these tests in two different ways, first, so that the impressions are received through the ear and, secondly, through the eye. The impressions which are given in either way must be given about the rate of one a second and the subject should, immediately after the series has been given, report, by speaking or writing, the impressions which he received. No apparatus is needed for the testing of memory in an auditory way, but the simple apparatus shown in Fig. 20 indicates how the words or figures or letters may be presented in a visual way. *A* is a sheet of stiff cardboard, 40 cm. long and 8 cm. wide, in the center of which is cut a 2 cm. square, *B*; *C* and *D* are strips of cardboard beveled at the inner edges, which are glued to the cardboard *A*, and *E* is a strip of cardboard 40 cm. long and 4 cm. wide, which runs between the strips *C* and *D*. The appearance of the apparatus in cross section at the portion of the arrows is shown in Fig. 20*a*. Many pieces like *E* are to be made, so as to contain the letters, words, digits, which are used, and the spacing between the individual letters, digits and words is to be made to accord with the size of the opening *B*.

The material which is used in these tests must be varied in accordance with the memory span of the subject. Some subjects are able to give correctly 8 digits, some are able to give only 6,

and some not more than 3. Similarly with letters and with words and with sentences. The normal amount which can be retained and reproduced varies with the different material which is utilized, but it may be said that usually seven digits are given correctly by normal individuals, 6 letters, 5 words, and about 12 words when the words are combined into a simple sentence. The

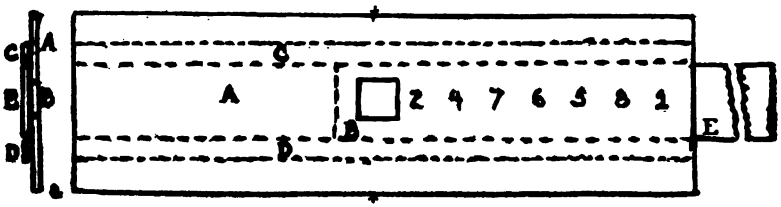

FIG. 20. Apparatus for exposing letters or figures in memory tests. *A*, front cardboard; *B*, opening, behind which figures are shown; *C* and *D*, strips acting as rails through which the stimulus carrier (*E*) is kept in alignment.

following list of digits, letters, words and sentences are suggested for these tests.

5–3–9–8–5–7–6–2–4–3.
4–3–8–6–7–5–3–9–2–1.
7–8–9–4–2–5–3–9–6–5.
8–3–9–2–1–4–3–7–5–1.
3–9–8–4–5–2–7–6–1–8.

8–5–7–2–4–9–8–6.
7–2–5–8–9–3–1–4.
3–5–2–7–4–1–9–7.
9–7–5–3–6–8–5–1.
6–5–7–8–3–9–2–4.

3–6–9–7–5–2.
1–8–3–6–4–5.
9–7–4–8–2–6.
8–6–2–7–1–4.
4–2–7–6–8–1.

1–6–5–8.
3–4–7–5.
5–9–7–2.
3–1–8–6.
5–8–2–9.

f–s–y–q–p–e.
k–z–o–h–n–w.
r–l–b–i–s–h.
x–f–k–v–a–l.
o–t–y–g–u–m.

c–x–e–n–u.
a–u–d–n–p.
q–i–c–m–v.
t–d–w–a–g.
r–v–b–p–o.

b–h–s.
g–y–l.
r–c–q.
f–t–i.
k–z–d.

bread—knife—collar—black—cat.
book—room—apple—grass—chair.
screen—paper—lamp—cork—ring.
coat—window—lake—head—glue.
cane—spoon—jug—hat—cheese.

She did not believe in ghosts.
It is dull work giving orders.
There were no bells in the house.
The nurse should keep her eyes open.
The garden is the place I go for refuge.
The pig-tailed monkey is an extremely amusing animal.
The birthday cake with its candles is a charming feature.
He took up his stand now with his back to the fire.
The eyebrows are two prominent arches covered with short but thick hair.
Unless the floor of the cage be hard, hyenas will burrow deep holes under it.
Myriads of stars were seen in the narrow black strip of sky over our heads.
The exciting political event of the month was the theatrical abdication of the French president.
All cleverness, whether in the rapid use of that difficult instrument the tongue, or in some other art unfamiliar to villagers, was in itself suspicious.
The election which was recently held has demonstrated the fact that most of our citizens wish good government and dislike the rule of the bosses.
Benches were built along the side of the house for summer use, and there was a great spinning wheel at one end of the piazza.
The handsome brown spaniel that lay on the hearth retreated under the chair in the chimney corner, and cowered until the two men had departed.
The door opened and a thick set man entered, with the flushed face and the gratuitously elated bearing which mark the first stage of intoxication.
The game of base ball is fast taking hold of the people of Canada who hitherto have been satisfied with the English games of cricket and foot ball.
The Hindoos believe that the gradual darkening of the sun during an eclipse means the jaws of a dragon are gradually eating it up.
Without map or compass the swallows come back each year to the places that have previously sheltered them.

Pen, ink, pencil, and paper have been the most potent factors in the advancement of the world in every way.

It will be noted that even though one sentence contains the same number of words as another it may be more complex in the number of ideas and this element must be kept in mind. This will be evidenced from the examination of the sentences which are given above.

(*c*) *Memory for Connected Words.*—A similar experiment in which pairs of words are used has been devised by Ranschburg. The subject is shown or told a pair of words, which he is instructed to repeat so that it is known he paid attention to and understood the words. Three, four, five or more pairs are thus given in a series and a minute after the last pair has been given the subject is asked to furnish the associated (second) words when the first of the pairs of the series are given. In tests of this character the associated words may be so closely connected in common speech that the test be useless for investigating the memory, and care must be taken that the words be associated but not too closely connected in common speech. Examples of the pairs of words too closely connected are as follows:

Bread—butter; knife—fork; cup—saucer; hand—foot; collar—cuff; eye—ear; tea—coffee; black—blue; watch—chain; night—day; coat—vest; pen—ink; dog—cat.

The following pairs of words are suggested as fulfilling the requirements of the experiment, but without the too close reflex association which has been mentioned above.

Head—hair; room—hall; chair—table; grass—tree; white—red; window—door; book—pencil; lake—river; apple—pear; pipe—tobacco; lamp—match; coat—cloth; paint—wood; clock—time; glove—hand; sponge—brush; sky—star; bird—feather; button—pin; oak—pine; water—ice; porch—chair; glue—wood; soap—towel; child—doll; bees—ants; law—judge; tea—sugar; square—round; duck—water; cow—horse; street—house; face—beard; actor—theater; potatoes—fish; dust—sand; cent—dime; bridge—river.

(*d*) *Memory for Complex Events.*—The experiments which have just been described are tests of memory for rather simple impressions. It is advantageous to learn how well more complex

events may be retained and for this purpose more complex material is to be utilized. In experiments of this nature the best material which can be utilized are pictures, postcards, photographs or illustrations from books or magazines. The method which I have employed is to select a series of ten or fifteen illustrations which on examination naturally group themselves into twos and threes with many points of similarity. Thus, for example, three illustrations of hats, three of boots, three of window curtains, three of bungalows, and three of automobiles may be clipped from the magazines and pasted on cards for this test.[1] Each of these pictures differs from the others in slight degrees, but each is very like the others in the set. Arrange these in sets so that there will be five original illustrations and the others duplicates and triplicates, with which the experiment may be done. The subject is shown for half a second a series of five illustrations (or three or six). The other ten (or six or twelve as the case may be) are arranged on a table in front of him, but behind a screen. Those which have been shown to him are then mixed with the others of the series and the subject is instructed to make a selection of the illustrations which he has seen. This method it will be noted is quite different from the method of reproduction. Here we deal with the kind of a memory which is called recognition. These tests may be varied by having the subject describe briefly the pictures which have been shown and thus we may also determine retention and recall abilities.

(*e*) *The Number of Repetitions for Memorizing.*—The memory capacity may be tested in a different manner, by the determination of the number of repetitions necessary for the subject to be able to reproduce a given series which can not be reproduced after one test. For this, a series of 12 digits, letters or nonsense syllables are used—the subject either reads these aloud or has them read to him, and after each 5 repetitions he attempts to reproduce the series. For example, the following results were obtained with a normal individual who was to memorize the series of 6–3–9–5–4–6–2–8–1–4–3–7: after 5 repetitions the first nine

[1] Several series of these pictures sufficient for testing the memory, etc., may be made by clipping illustrations from old magazines, catalogues of department stores, instrument houses, etc., and these pictures will be found useful in many other tests.

digits had been learned, and after ten the series was reproduced completely and accurately.

The following example was read to a normal subject and after each reading he attempted to reproduce the whole, with the following results:

Example: 4 9 6 2 8 7 5 3 1 6 4 7.

Results:

After	1 reading:	Nothing.
"	2 readings:	4 9 6 2
"	3 "	4 9 6 2 8 5 7 3
"	4 "	4 9 6 2 8 7 5 3 1
"	5 "	4 9 6 2 8 7 5 3 1 6 8 7 4 1
"	6 "	4 9 6 2 8 7 5 3 1 6 7 4
"	7 "	4 9 6 2 8 7 5 3 1 6 4 7
"	8 "	4 9 6 2 8 7 5 3 1 6 4 7

From the results of this test it will be seen that this subject divided the example into three parts, each containing four digits, and in this way learned the first four digits, then the second four, and finally attempted to add the third four.

(*f*) *Memory for Connected Trains of Thought.*—This test is similar to the test *b*, given above, being an extension of the sentence part of that test. Longer stories are given and the subject is asked to reproduce the sense, giving the idea elements of the story and not the particular words. For this purpose the following stories are used:

Once upon a time there was a girl, whose father and mother were dead, and who was so poor that finally she had nothing but the clothes on her back and a little piece of bread in her hand. She was deserted by everybody, but since she was good and honest she went into the world with confidence in God. As she went along she was met by a poor old man who said, "Give me something to eat, I am hungry." The girl gave him the piece of bread and went on farther. Soon afterwards she encountered a little girl freezing and almost naked, who begged for clothes. The good girl gave the poor child the warmest of her garments. Night came on, the good girl was tired, cold and hungry. She travelled into the woods, and, wandering off the road, she knelt and prayed to God. As she knelt she saw the stars falling about her, and when she looked she found they were many bright gold dollars.

The son of a Governor of Indiana was first officer on an Oriental steamer. When in the Indian Ocean the boat was overtaken by a typhoon and was violently tossed about. The officer was suddenly thrown overboard. A life preserver was thrown to him, but, on account of the heavy sea, difficulty was encountered in launching a boat. The crew, however, rushed to the side of the vessel to keep him in sight, but before their shuddering eyes the unlucky man was grasped by one of the sharks encircling the steamer and was drawn under the water, leaving only a dark streak of blood.

It is related that at the coronation of one of the Popes about three hundred years ago a little boy was chosen to act the part of an angel; and in order that his appearance might be as gorgeous as possible he was covered from head to foot with a coating of gold foil. He was soon taken sick and although every known means were employed for his recovery, except the removal of his fatal golden covering, he died in a few hours.

A female polar bear with two cubs was pursued by sailors over an ice field. She urged her cubs forward by running before them, and, as it were, begging them to come on. At last in dread of their capture she pushed, then carried and pitched each before her, until they actually escaped. The polar bear is a wonderful swimmer and diver. In the capture of seals lying on the ice, it dives some distance off and, swimming underneath the water, suddenly comes up close to the seals, cutting off their retreat to the sea.

A cow-boy from Arizona went to San Francisco with his dog which he left at a dealer's while he purchased a new suit of clothes. Dressed finely, he went to the dog, whistled to him, called him by name and patted him. But the dog would have nothing to do with him in his new hat and coat but gave a mournful howl. Coaxing was of no effect, so the cow-boy went away and donned his old garments, whereon the dog immediately showed his wild joy on seeing his master as he thought he ought to be.

One day Mr. Lincoln was out riding. As he passed along the road, he saw a pig sinking into a mud-hole. Poor piggy would climb part way up the slippery bank, then down he would fall again.

"I suppose I should get down and help that pig," thought Mr. Lincoln. "But I have on my new suit, and it will be quite spoiled if I do so. I think I'll let him get out the best way he can."

He rode on. When nearly two miles away, he turned and came back. Not minding the new clothes, he stooped, and taking piggy in his arms, he dragged him out of the mud.

The new suit was quite spoiled, but Mr. Lincoln said he had taken a pain out of his mind.

A young man worked years to carve a white marble statue of a beautiful girl. She grew prettier day by day. He began to love the statue so well that one day he said to it: "I would give everything in

the world if you would be alive and be my wife." Just then the clock struck twelve, and the cold stone began to grow warm, the cheeks red, the hair brown, the lips to move. She stepped down, and he had his wish. They lived happily together for years, and three beautiful children were born. One day he was very tired, and grew so angry, that, without cause, he struck her. She wept, kissed each child and her husband, stepped back upon the pedestal, and slowly grew cold, pale and stiff, closed her eyes, and when the clock struck midnight, she was a statue of pure white marble as she had been years before, and could not hear the sobs of her husband and children.

It will be seen that these stories differ considerably from one another, both in the number of ideas contained in them and in regard to the emotional character of the story itself. In estimating the ability of a subject to remember a story, these are two elements which must be considered.

If the emotional content in stories is of such character that it is overpowering it may bring about an inhibition or mental stasis or even a memory loss for impressions which have preceded. Those stories which have an emotional part at the end, when this emotional part produces an emotional reaction on the part of the individual, often leave the subject able to repeat only the last or the emotional idea. This will be evidenced by the results obtained with the second of the stories, that of the shark. Some patients who are affected by the emotion-producing last sentence are able only to recall or to repeat, "There was a dark streak of blood." The rest of the story appears to be lost. The polar bear story, on the other hand, has no particular emotional content, and the ideas contained therein are given fairly well by normal individuals and the number of ideas reproduced by the abnormal depends upon the memory span. On the other hand, it must be remembered that reaction to the emotional part of the story gives some indication of the character of the individual even if it does disturb the memory process. It is, therefore, advisable in testing the memory by such complex material as this to have the stories of two different characters, those which are emotionally colored and those which are made up of emotionally colorless material. By doing this not only the memory but the emotional condition of the individual may be determined.

(*g*) *Memory for School Subjects, etc.*—It is advantageous to discover the character of the memory for facts learned rather

early in life, and one of the best methods of determining this is to question the subject regarding the topics which he learned in school. Numerous tests in the form of questions may be made but the questions must be fitted to the individual subject since the amount of education varies to a great extent. In the questions which are suggested it will be noted that a number refer to topics which may not be taken up in the elementary schools, but to those which are considered in the higher grades or in college.

Have the subject repeat forwards and backwards the following and record exactly what he says: the alphabet; the names of the months; the days of the week; the names of the seasons.

Examine the patient in regard to his special memory of geography and history:

Which is the longest river in the U. S.?

What is the capitol of the U. S.?

Name five states in the West and give their capitols.

Name the five largest cities in the U. S.

Give the dates of the most important wars of the U. S.

Tell with what countries they were fought.

Name some of the most noted presidents.

How often and how are the senators of the U. S. elected?

Name some of the most important countries in Europe, and give their capitols.

What forms of government have the following countries, and give the titles and names of the present rulers: Canada; England; France; Germany; Italy; Portugal; Spain; Switzerland; and the U. S.

With what country is Australia politically connected? Egypt? Java? Madagascar? Porto Rico?

What is Armenia? Barcelona? California? Finland? Gambesi? Gibraltar? Hamburg? Malta? Persia? Vienna?

Who was Bonaparte? Anne Boleyn? Brian Boru? Brutus? Cæsar? Cicero? Cleopatra? Crœsus? Diogenes? Elizabeth? Grant? Lincoln? Peter the Great? Pliny? Robespierre? Sherman? Socrates? Victoria? Washington? Wellington? Xenophon?

Give the names of three eminent dead authors, and tell in what language each wrote.

Who was Addison? Chaucer? Corneille? Dickens? Dumas? Emerson? Goethe? Grimm? Homer? Horace? Hugo? Longfellow? Poe? Racine? Schiller? Scott? Shakespeare? Tennyson? Thackeray? Vergil? Give the names of their works.

Who was Diana? Venus? Jupiter? Hermes? The Furies? The Sibyls?

Who was Darwin? Galileo? Gutenberg? Herschel? Huxley?

Who was Michael Angelo? St. Gaudens? Raphael? Rembrandt? Rubens?

Who was Beethoven? Mozart? Wagner?

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See also references 2, 8, 11, 17, 19 (Chap. I), 128, 129, 134, 135 and 138 (Chap. X).

CHAPTER VII

ASSOCIATION

It is unfortunate that the term association has been used in so many different senses, because we often find the discussions about this topic confusing on account of a mixture of conceptions of the meaning of the term. It is not uncommon to find an author using the word in its psychological, physiological and anatomical meanings, without any indication of the differences, and it is this kind of inaccuracy that makes the study of association literature very difficult.

Four distinct meanings are attached to the word association: (1) It is the name given to the anatomical connection of cerebral or other nervous elements; (2) it is the term descriptive of the physiological processes which accompany the activity of these closely connected anatomical elements, whether the physiological phenomena are accompanied by consciousness or not; (3) it is used as the name of the mental process or processes accompanying the activity of the closely related cerebral areas or cells; and (4) it is the designation of the mental results of the physiological processes. It is believed that we have processes or conditions corresponding with all the meanings which have been given to the term, but what the relation between the different processes may be and what has produced the different conditions is not to be discovered by calling these four things by one name, by using the name indiscriminately and by invoking one conception to bear out our conception of another.

When we receive a stimulus, in some manner the perception which we have of this stimulus is accompanied by other mental things. These things may be pictures, sensory or motor, or ideas, and they have been called associations. Thus when we hear the word horse, it may bring up a picture of a horse, definite or indefinite, or it may bring up an idea of a team with its wagon, or it may call up other things which we feel have some relation with the stimulus but which is not contained in the stimulus. The mental things which accompany the percept or con-

cept which has been due to the stimulus we call associations. These associations may differ in innumerable ways, *e. g.*, in definiteness, in congruity and what not, but they are all associations. The mental state which has been initiated may continue and it may result in the having of numerous other ideas which are more or less logically connected with the original impression, but which on the other hand, may appear to have no relation to the stimulus. All of these ideas have a sequence in time, and when this has been said it is approximately all that can usually be definitely and accurately stated.

The ideas, which we decide to call associations, may be looked at in different ways. We may select to consider them as distinct occurrences, and seek to see what relation they may have to each other, or we may select to consider them a series and seek to consider why they occur. In doing the first we try to deal with the associations in what has been called a static manner, and when we try to consider the "why" of the series we attempt to deal with them in a dynamic manner. What is given is a series, and this series may be accurately defined in a static manner, but the seeking for a "why" leads us into the realm of hypothesis. For a complete understanding of the associations we must, however, have both of these matters determined, although it must be kept in mind that the dynamic considerations or conclusions are deductions of what has happened and the static are conclusions of our own ideas of what formal or logical relation of the ideas is the more satisfactory and least liable to error. This is the method which has been closely followed by most experimenters, and has been the most fruitful in giving an understanding of the laws and the forms of the associations.

When the word fire is given to you it may produce not only an idea of fire but also the idea "burn" or "match" or a "house burning" or "light," or numerous other things. Similarly with any other stimulus, auditory, visual, tactile, etc. In normal people the first idea or association following the idea contained in the stimulus comes after a quarter or a half second, although this time may be considerably increased under certain conditions. It is also known that the character of the associations differ in different people, and that in some cases the experimenter can not classify directly the idea which has been reported to him as

associated with a stimulus or with another idea. In other words, to one other than he who experiences the association, certain associations appear to have no connection with the perception or the preceding idea. Associations of this character have been called mediate associations in contradistinction to the immediate associations the relation of which to the stimulus or to the preceding idea is clear to the experimenter. The mediate associations are, on the other hand, sometimes clearly related and sometimes they can be analyzed and found to be due to the suppression of an element or to lack of vividness of an element which has not been reported. These mediate associations are of much interest because of their occurrence in pathological conditions or states, and because of their indication of suppression.

Both the immediate and the mediate associations have been investigated very carefully and fully, and certain laws of association have been formulated from the experimental work which has been performed. It has been found that after two stimuli have been given several times in successive moments of time there is a tendency for the individual to have ideas of both of these when only one is presented. Numerous almost universal examples of this can be given, *e. g.*, hat and coat, shoe and stocking, day and night, white and black, etc. These two impressions or ideas have been obtained together so often that immediately one term is given the other also springs up in mind, and there is a tendency to a constant type of reaction. This is the most powerful of the influences affecting associations, and following the results of the experimental investigators we may say that repetition defines or limits associations. The next element in experience most effective in the determination of associations is that of vividness. If an experience has a strong emotional coloring, if it has produced great changes and reactions in you, the whole, with its attending ideas, tends to be brought up at any time that a part of this experience is repeated, *i. e.*, whenever a stimulus is given which is like that of the old, or like part of the old. The having been in a situation in which the fear element predominated, let us say when in the dark and there were suspicious noises, produced a mental set or tendency which, whenever a part of the experience is repeated, *e. g.*, when the words "dark" or "noise" are heard tends to bring to mind the total occurrence. In other words,

"dark" has associated with it the rest of the previous experience. The recency of a situation is another factor in the formation of certain associations and in the ability of revival of it. If two hitherto unconnected impressions be presented, *e. g.*, the nonsense syllables lub-frun, and then immediately the first or the second of the two be given the other one is also brought to consciousness and is said to be associated because of its recency. If these two meaningless syllables are said without your having had a particular attitude or interest towards them and an intermission of a minute or two be given the repetition of one may fail to call up the other. If there be added to the situation of the first series of stimuli the condition of interest the connection of these two meaningless words may remain and they may be associated whenever one of the two is presented. These then are the most important laws of association: repetition, or frequency, or the time during which the original impression persisted; vividness, or the mental intensity which the original impressions had; and recency, or the time between the original impression and the present moment.

The kinds of associations are extremely numerous. There are the visual with the visual, the visual with the auditory, the visual with the tactile, motor, olfactory, gustatory, and other kinds of sensational-like ideas, and there are all the combinations of the other senses with the visual and with each other Such a conception or division helps only in the formulation of associations according to their sensory or perceptual qualities, and gives no further indication than that of quality. There are, however, other ways in which the associations may be considered, *e. g.*, the grouping of the associations into formal groups according to certain logical characteristics. All the so-called laws of association except those of repetition, vividness, recency, primacy and emotional congruity (the latter two of which I have not previously mentioned) are really logical classifications of associations according to the view of the experimenter of the possibility of similar associations in his own mind. The most familiar type of these classifications is that of Aristotle, which has been used down to very recent years: similarity and contrast, coexistence and succession. Three of the numerous other classifications which have been proposed are given in the tables, not so much because they show anything more or any better than that of Aristotle what

takes place in association, but only to give some conception of the numerous ways in which the associations have been grouped. That of Kraepelin, constructed as an explanation of associations obtained by him in experimental work in 1892 shows a slight advance in a logical way, and for purposes of grouping the more elaborate scheme of Claparède may be taken to represent only the addition of certain associations, determined by experimental inquiry, which could not be decisively classified according to the scheme of Kraepelin and his successors up to the time of Claparède. The third classification, that of Kent and Rosanoff, is an attempt to classify on a "frequency" basis, which is used by them as a criterion of abnormality. Even with this elaboration it is at times difficult to classify certain associations, and at times it is impossible to class some. Kent and Rosanoff report 91.7 per cent. of common, 1.5 per cent. of doubtful, and 6.8 per cent. of individual reactions from their series of tests on 1,000 subjects, and it is worthy of note that they place over one third of their individual reactions among the "unclassified." An excellent illustration of the difficulty of classification is given in the example by Arnold "of the soldier who said he was wounded, once in his leg and once at Marengo." Here the association might be stretched to be divided into two and classified according to temporal and spatial coexistence, although in the mind of the man there was probably only one idea. The division of Claparède "without worth" probably will not hold, for all associations must have worth for the individual even though the experimenter see no worth in them. A good example of this is the associations in certain forms of dementia præcox, which are termed "neologisms." If a patient who shows such associations writes a letter in which there are numerous neologisms, it may be unintelligible to you, but hand it to the man or woman who wrote it, ask him or her to read it, and he or she will do so with a serious face and with apparent understanding. The neologisms undoubtedly have a meaning to the one who coins them, and it is only in the logical arrangement of associations in accordance with the ideas of the experimenter that they have no meaning or worth.

The variety of associations which one subject may have is determined by the previous experience. The astronomer, as well as the average man, has an association with the word "star." But

Classifications of Associations

Kraepelin, 1892

1. Outer associations.
   - (*a*) Spatial and temporal coexistence.
   - (*b*) Verbal reminiscence.
   - (*c*) Assonance.
2. Inner associations.
   - (*a*) Coordination and subordination.
   - (*b*) Predicative relation.

Claparède, 1903

1. Without worth.
   - (*a*) Unintelligible.
   - (*b*) Assonance.
   - (*c*) Free revival.
2. Worth deadened.
   - (*a*) Single reaction.
   - (*b*) With selection.
3. With actual worth.
   - (*a*) Predetermined.
   - (*b*) Free.

} Coexistence, coordination, subordination, cause, effect, etc.

Kent–Rosanoff, 1910

1. Common reactions.
   - (*a*) Specific.
   - (*b*) Non-specific.
2. Doubtful reactions.
3. Individual reactions.
   - (*a*) Normal.
   - (*b*) Pathological.
     1. Derivatives of stimulus words.
     2. Partial dissociation.
     3. Complete dissociation.
   - (*c*) Unclassified.

the associations in the case of the specialist differ from those of the man who is not an astronomer on account of a different mental state or mental content or apperception mass. It is well known, that on account of previous training the associations of the physician differ from those of laymen, and certain words have not only different associations combined with them, but certain words which are of no worth, or of no associative power, for the layman have a considerable associative effect upon the medically trained individual.

So far we have been concerned with the characteristics of association and have said nothing of association itself. What is association? is a question that has often been asked, but just as often unsatisfactorily answered. Titchener says "association of ideas is one of the most familiar and one of the most slippery phrases in psychology." Arnold, who has made a careful analytical study of the matter, gives two general views which are held of association: first, that it is a mental something already existing, due to previous processes; secondly, that it is simple recall or process of revival. In the first, as Arnold says, the emphasis is laid upon the first member in the revival, in the second the second member in relation to the first is considered. "Considered as a cause, therefore, association is the functional development of a psychophysical disposition. As an effect, it is the realization in serial order of the continuity implicit in the present moment." In other words, as a process it is the passing of the mind from a presented situation to an idea or from one idea to another, and, as an effect of the process, association is a sequence of ideas. We may say, then, that associations are serial ideas or one idea following another, or, objectively, they are reactions indicating the presence of ideas.

Tests of Associations

How may associations be investigated? With sufficient knowledge of the individual reactions, in the form of speech it may not be necessary to make any special tests. All the associations of which an individual may be capable may be brought out in conversation if the conversation covers a sufficiently varied and wide field and if we can catch all the words and expressions which are emitted it is possible to determine the general character of the

associations. In following such a method, however, we must bear in mind that many expressions of speech are almost reflex in character, and that they are no more an indication of the presence of an idea than the movement of the leg is evidence of the feeling of the stimulus which has been applied to the patellar tendon. In considering voluntary speech as a means of determining the number and character of the associations it must be remembered that we are always continually introducing new stimuli, awakening new sense organs, and that by doing so we are doing what is done in a series of association tests, viz., introducing to the subject new stimuli which are intended to result in reactions which indicate the presence of certain mental elements not contained in the original stimulus. For convenience, however, several kinds of tests have been devised. These tests have been varied so that they take in numerous sense fields, but usually the stimuli have applied to the visual and auditory organs because of the ease with which these kinds of stimuli may be given. It is this form of association test which has been found so useful in bringing out certain abnormal, or rather not normal, reactions, and which has given us an insight into the kinds of associations which the individual has.

(*a*) *Association of Single Ideas.*—The subject is given a stimulus, usually a word, either visual or auditory, and instructed to report the first associated idea which comes to mind after the stimulus has been given. For the convenience both of the subject and the experimenter the subject should be instructed to give this idea as far as possible in one word. The exact answer or reaction must be accurately recorded and the records will then be available for careful study.

In addition to the association itself it is advisable that the time between the giving of the stimulus and the reporting of the idea be recorded. This time may be measured by the use of elaborate instruments such as the Hipp chronoscope, or the Ludwig kymograph, but for all diagnostic purposes recording of the time to the thousandth, hundredth or even to the tenth of a second is unnecessarily wasteful of the time of the experimenter. For the association tests used with abnormal subjects it is sufficient that the time be recorded to the nearest second or half second, to the nearest fifth second if one wishes to be more exact.

The association times vary with individuals, some subjects reporting their associated ideas on an average about one second after the stimulus has been given, while others average three or four seconds.

In a series of associations it will sometimes be found that certain reported ideas have been given only after a much longer interval than others. Many of these, it has been found, are not the first ideas which the stimuli have called forth, but secondary ones. In these tests careful analyses have shown that the first idea has been repressed or concealed, and because of this repression additional time has been needed so that a secondary idea shall be reported. These secondary associations are mediate associations in time, although, as far as the logical character is concerned, they may appear to be immediate. It is by reason of this increase in time that certain reactions which appear to be logically normal are detected to be abnormal. This has led to the discovery of certain hidden associations which the subject feels are improper or inadvisable to report. It has been shown above that the previous education and experience of the individual affect the character of his associations. Certain of the associations which are reported by a normal individual differ greatly from those of other individuals, but when many individuals are tested it is found that the associations which usually arise when certain stimuli are given have certain definite characteristics. This matter has been considered in some detail in the work of Kent and Rosanoff. These authors show that certain stimuli produce in certain subjects reactions which are individual in character and these individual reactions may to some extent be considered abnormal. Although they have been considered to be abnormal the individual or unusual reactions do not, however, always indicate an abnormal association, and they can not always be taken to indicate the presence of a submerged or hidden complex. They may be evidence only of a paucity of ideas; *e. g.,* in the test in which the word "slow" was given as the stimulus the association "slowly" was reported; in another test the stimulus "river" brought forth "rivulet"; "sleep," "sleepy"; "hand," "handy"; "comfort," "comfortable"; etc. It would appear that the stimulus probably has not brought forth a new association and the subject reports an idea which is very much like the stimulus which has been received.

On the other hand, I can also understand that an association reported in the Kent-Rosanoff series with a relatively great frequency may yet be abnormal for the individual. For example, a subject who because of an emotional experience normally has the association "cheek" with the stimulus "red" may report a delayed association like "blood," and this because of its frequency among normal people has an appearance of normality. The time of the appearance or of the enunciation of the associated idea in a case like this would probably give an indication that the association which appeared first had been repressed and that the reported association was one "manufactured" for the experimenter. Moreover, an association of an individual character may in itself be normal, but appear to be abnormal if it is dealt with in accordance with the frequency table method alone. The association "table—cockroaches" was reported only once in the Kent-Rosanoff series but this association would be perfectly normal for that individual who has disgust for these vermin and who, just previous to the test, has seen one crawl over the table at which he has been eating. From these considerations it will be appreciated that neither the frequency nor the time taken singly may be considered to be good evidence of abnormality. Both of these elements must be taken into account and neither is of more importance than the other. On the other hand, the combined logical and frequency values of the reported associations are not always a safe guide in the estimation of the abnormality of a single association, although they are undoubtedly of great assistance in the estimation of abnormality of the individual if he gives a number of individual and "without worth" reactions in a series.

With some subjects certain words have such an emotional effect that they cannot be used in a series of tests of this character because only mediate associations will be given, and the times of reaction will be very long. It is, however, not always easy to tell just what words will produce in a given individual such an effect and for this reason the words which are used in a series should be carefully scrutinized if the test is to be made for diagnostic purposes. For diagnostic purposes it is always advisable to insert in the list of stimulus words certain ones which the experimenter thinks will have an emotional effect, and it is almost needless to

state that these words should be changed in accordance with the elements supposedly suppressed by the subject who is being tested. In selecting words for their emotional effects the experimenter must bear in mind the fact that words which he may select as suggestive in regard to certain situations may not be suggestive to the individual who is being tested. If the results of the experiment show that these words have not produced an emotional effect upon the subject and that the reactions are normal both in character and in time the experimenter should give up his own preformed ideas of what ought and of what ought not be considered suggestive in the individual case. Because of the impossibility of determining what will and what will not be suggestive in particular cases no special lists of suggestive words are given but these words should be selected by the experimenter for the individual situations and cases. The criticisms made above should be kept in mind and, in addition, it may be mentioned that the selected suggestive words should be mixed with other supposedly non-suggestive words (such as those of the Kent-Rosanoff series), which have been shown in most cases to give normal reactions. In a series of 100 association tests the experimenter may insert words here and there to the number of twenty-five or more in an irregular order. It is sometimes convenient to have a definite order for the insertion of the suggestive words, the subject, of course, not knowing what the order is. The two following orders are suggested for the special words: (*a*) 4th, 7th, 11th, 14th, etc., with three and two normal stimulus words respectively between the suggestive words; and (*b*) 4th, 9th, 13th, 18th, etc., with three and four normal words between the special words.

On account of the fact that we have frequency tables only for the words in the Kent-Rosanoff series, these words are recommended for the normal words in association tests, so that the reactions of the individual may be compared with the reactions of the 1,000 normal people whom these investigators tested. A list of these words is given in the accompanying table.

KENT-ROSANOFF LIST OF STIMULUS WORDS FOR ASSOCIATION TESTS

table	wish	stem	bitter
dark	river	lamp	hammer
music	white	dream	thirsty
sickness	beautiful	yellow	city
man	window	bread	square
deep	rough	justice	butter
soft	citizen	boy	doctor
eating	foot	light	loud
mountain	spider	health	thief
house	needle	bible	lion
black	red	memory	joy
mutton	sleep	sheep	bed
comfort	anger	bath	heavy
hand	carpet	cottage	tobacco
short	girl	swift	baby
fruit	high	blue	moon
butterfly	working	hungry	scissors
smooth	sour	priest	quiet
command	earth	ocean	green
chair	trouble	head	salt
sweet	soldier	stove	street
whistle	cabbage	long	king
woman	hard	religion	cheese
cold	eagle	whiskey	blossom
slow	stomach	child	afraid

In addition to what has already been said regarding the detection of the abnormal character of associations, it should also be noted that occasionally a stimulus produces an associational disturbance which is shown in reactions other than that following the immediate disturbing stimulus. The emotional disturbance is sometimes found only after a new stimulus has been given and at times the disturbance extends over three or four reactions, which are supposedly normal. This is evidenced by a lengthening of the time of the responses. For example in a series of tests of normal subjects the following results were obtained:

Stimulus	Association	Time in Sec.
book	reading	1.2
ink	writing	2.4
leg	clothes	4.0
coat	door	4.6
black	night	3.8

Stimulus	Association	Time in Sec.
pencil	write	2.0
woods	forest	2.4
road	travel	2.8
apple	red	4.4
to meet	come together	6.0

In the first example we find that the suggestive word "leg" produced a longer reaction than the normal and the emotional disturbance due to an attempt at repression continued over two other reactions. In the second example the suggestive word "road" was followed by a reported association with a normal time interval, but the two succeeding associations were disturbed and their times lengthened.

The test which has been described and discussed is sometimes repeated after an interval of an hour (or a day or two weeks, the time interval differing according to different experimenters) and a comparison is made of the reported associations in the two series of tests. Those stimuli which have an emotional effect are usually disturbing in both series of tests and it is easy from a comparison of the two series to determine those words which do and those which do not touch upon some secret or hidden ideas of the individual.

(*b*) *Serial Association Test.*—A test of associations somewhat similar to that just described is made by giving the subject a stimulus which is to be taken as the starting point for a series of associations instead of one association. The subject is instructed to report not only the first association which arises but a sequence of associations. For example, to the stimulus "horse," the following series may be reported: "wagon—man—wheel—road—bridge—river—fishing—vacation," etc. Here, the stimulus word has an immediate effect on the production of the first association, but each of the subsequent associations depends upon the idea immediately preceding. In certain pathological cases it is found that when this process of reporting successive associations is continued the subject will eventually either bring forth the same idea time and time again, thus indicating the compulsive trend of his thought, or give evidence of certain pathological ideas by the manner in which certain associations are reported, *e. g.*, in the retardation between associations and in the enunciation of mediate associations. This test may be performed with

any of the words of the Kent-Rosanoff list as stimuli since the original stimulus word has very little to do with the determination of the pathological reactions. The time for the series should be recorded and a note made of delays between reactions. After a series of associations has been recorded, it is advisable to go over those which appear abnormal, logically or because of their individual character, and those which have been reported only after long intervals of time. The subject should be carefully questioned to see whether or not he can give any reason for the mediate associations and for the time delays.

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See also references 2, 8, 19 (Chap. I), 115 (Chap. VIII), and 134 (Chap. X).

CHAPTER VIII

CALCULATION TESTS

Although tests of calculation ability are considered by some authors to be mainly tests of the permanency of associations, such a view will hold only for those tests in which simple calculations are made, *e. g.,* those of adding two or three digits, of multiplying digits under ten, etc. The more complex arithmetical problems, however, bring into play other mental processes besides that of association. In a general way it may be said that the calculation experiments are tests of these more complex mental processes and that these processes include much of what is called "thinking" and "judgment" as well as association. Previous tests which have been made have, in fact, often been considered under the heading of "thinking" tests and they may for convenience be grouped under this name.

The tests which are suggested here are the simpler calculation tests and these are divided into three groups. The first group includes various kinds of addition tests. The second includes the more complex tests of multiplication, subtraction and division, and finally the third group includes what in school work is called "mental arithmetic." All these tests may be carried out in two ways: (1) They may be performed with the figures before the individual so that he may see them and write or vocalize his results, or (2) the individual figures may be read to him and the results given by him vocally.

Tests from (*a*) to (*e*) may be used not only for the purpose of determining the ability to calculate but when performed in series, as they are arranged, they are useful for determining the amount of mental work and mental fatigue. If they are used for the latter purpose the subject should be instructed to perform the calculation for each problem and write the result as quickly as possible; turn to the next problem, perform it as quickly as possible, and so forth until the end. With a little practice the experimenter will be able to record the times taken by the subject for the performance of the individual problems

and by a comparison of these figures an estimate may be made of the fatigue effect resulting from the long continued work. For tests of this character I believe the more complex problems, viz., those with three (*d*) or five (*e*) digit figures to be better than those with one (*b*) or two (*c*) digit figures, except in the case of relatively uneducated subjects.

The ability of the individual is to be determined in two different ways, first by the accuracy with which he performs the arithmetical calculations and secondly by the time which is taken for the performance of the work. The long series of single digits (test (*a*)) can not well be used for the determination of accuracy because one mistake may be made in the calculation of the series of ten digits or two mistakes may be made and the same addition result be written by the subject. For this reason, therefore, tests (*b*), (*c*), (*d*) and (*e*) are better because individual mistakes may be noted and counted.

In the selection of tests for any particular subject one should bear in mind his general education and ability, and the tests should be given in accordance with these. Test (*b*), for example, can not be used to give an indication of abnormality in many classes of patients because this test results only in the determination of the permanency of association, which may be perfect. It is, however, necessary to use this test with the least educated although it may be said that I have found tests (*d*) and (*e*) to be most satisfactory with a great proportion of patients.

Calculation Tests

(*a*) *Addition Test, Ten Single Digits*

9	3	8	6	7	3	3	4	6	4
7	5	7	8	8	2	5	3	9	2
8	9	9	9	9	7	7	6	7	6
3	8	3	6	7	9	1	8	6	1
2	8	2	3	6	7	4	3	9	3
4	7	6	4	5	6	7	4	3	5
2	6	3	7	4	2	5	9	1	7
6	2	1	9	8	5	3	2	1	7
8	9	6	8	3	8	2	6	5	2
1	8	9	5	2	7	9	7	7	9

(*b*) *Addition Test, Two Single Digits in Series*

2	6	8	4	8	5	1	9	3	4
5	9	6	7	9	2	4	3	2	3
2	6	7	8	9	5	1	9	5	4
3	2	6	6	6	8	4	5	8	2
3	8	7	6	8	5	4	3	6	9
6	8	2	9	3	7	3	5	9	3

(*c*) *Addition Test, Two Digit Figures, in Series*

79	74	92	94	72	42	23	63	35	83
63	76	35	42	62	67	92	81	24	52
97	73	62	57	66	94	59	58	34	81
87	97	94	64	19	87	23	36	51	58

(*d*) *Addition Test, Three Digit Figures, in Series*

944	516	421	167	269	848	116
117	194	588	946	213	193	151
925	417	692	757	352	216	378
589	765	139	792	742	418	554
321	634	635	762	126	463	
848	234	235	638	189	594	

(*e*) *Addition Test, Five Digit Figures, in Series*

86493	54631	92237	93183	18342
11672	84842	26923	48763	69235
35561	81142	29618	77629	22287
15162	19367	31392	76581	13924
93916	32691	61855	75776	12238
35273	63494	32166	37957	21662
54241	59332	79539	96124	28847
74297	23487	84819	55464	48194

(*f*) *Simple Arithmetical Tests; Addition, Subtraction, Multiplication and Division*

73 + 22	63 — 7	7 × 6	63 ÷ 7
56 + 18	81 — 12	5 × 8	72 ÷ 9
76 + 12	68 — 27	9 × 13	56 ÷ 8
90 + 18	96 — 19	4 × 16	15 ÷ 3
14 + 28	54 — 19	6 × 18	24 ÷ 6
84 + 25	87 — 24	11 × 12	45 ÷ 5
42 + 64	89 — 36	8 × 7	90 ÷ 15
106 + 17	192 — 16	12 × 14	132 ÷ 11
127 + 315	258 — 169	21 × 9	156 ÷ 13
137 + 64	246 — 35	18 × 21	192 ÷ 16
642 + 187	643 — 347	26 × 13	288 ÷ 16
498 + 327	576 — 253	14 × 11	187 ÷ 11

(*g*) *Mental Arithmetic Test*

You have 50c.; you buy cherries for 12c., butter for 7c., and bread for 10c.; how much change do you have?

You use 25 cigars a week at 10c. each; how much would you save if you bought 100 by the box at 7½c. each?

You have $1.57; and buy 5½ yds. of muslin at 7c.; how much have you left?

You have 78c.; and buy 6 handkerchiefs at 8½c. each; how much have you left?

You sell a 120 lb. pig at 4c. a lb.; and 6 hens at 25c.; how much do you get?

You sell a house for $5,200 and its furnishings for $1,850; and buy a farm, house, barn, etc., for $3,500. How much have you left for repairs, and the purchase of furniture, implements, etc.?

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See also references 19 (Chap. I) and 122 (Chap. IX).

CHAPTER IX

TIME OF MENTAL PROCESSES

The simplest mental process the time of which may be measured is called a simple reaction. This is a consciously determined response or movement following a definite stimulus, *e. g.*, the flexion or extension of a finger when a beam of light is thrown into the eye. Other reactions are or may be simpler than this but the latter are usually grouped under the heading of reflexes. For example, the movement of the eyelid or eyeball when a beam of light is thrown into the eye is not consciously determined, but is due to a close physiological and anatomical connection of nervous elements, the activities of which are not necessarily accompanied by consciousness.

The simplest conscious process of which we are aware is that of the simple reaction. This process is, however, physiologically complex, for it is known to be made up of a number of elements some of which are unconscious as well as conscious. The total time of a simple reaction comprises the times for a number of separate physiological events. It is made up of (*a*) the time it takes for the end organ to be set into activity by the stimulus, (*b*) the time for the transmission of the impulses to the cerebrum through connecting chains of neurons, (*c*) the time for the initiation of an impulse and for the passage of this from the sensory or perceptive centers in the cerebrum to the motor or emissive centers, (*d*) the time for the initiation of an impulse by and the transmission from these centers and through the various neurons connected therewith into the spinal cord and the nerves to the muscles, and, finally, (*e*) the time it takes for the muscles to react and to move a particular part.

The latent period of a reflex has been found to be approximately 0.05 second, the simple reaction time may be considered to be about 0.1 second. We may, therefore, say that in the simple reaction the time consumed in the physiological processes associated with the mental act is approximately 0.05 second. This time

it must be understood, has not been accurately determined and is only a very rough approximation.

It has been demonstrated that most of the time taken in the transmission of the impulse to the cerebrum is consumed in the sensory end organ and in the traversing of the synaptic connections, and that most of the time for the transmission of the efferent impulses from the cerebrum is taken up in crossing similar synaptic connections. The rate of the nervous impulse, both sensory and motor, is known to be rapid and only a comparatively small amount of time is consumed in the passage of the impulses along the nerves. Much of the time consumed in the simple reaction must, therefore, be taken up in the passage of the impulse from one part of the brain to another, and this supposition is strengthened by the fact of the lengthening of the time whenever more complex mental processes are to be performed.

It has been found that the time taken up in the retina when a light stimulus has been given is approximately 15 σ.[1] The latent period of muscular contraction is between 5 σ and 10 σ, and the transfer at the synapses takes from 12 σ to 20 σ. The rate of transmission of the nerve impulse is about 50 meters per second for the afferent and about 40 meters for the efferent nerves. When all these times have been taken into account it will be seen, as has been said above, that most of the time consumed in the simple reaction is due to the physiological processes taking place in the higher centers, and especially in the cerebrum. How much time in any particular case is actually taken for those physiological processes which are accompanied by consciousness we did not know. We may, however, compare the time for the simple reactions with those of the more complex reactions, and in that way determine the extra time taken for cerebral processes in conjunction with these more complex mental processes.

The simple reaction time when the stimulus is given to the eye averages about 150 σ; to the ear about 140 σ; to the skin, when the stimuli are tactile, 110 σ, but when they are thermal, 170 σ.

If the subject be compelled to make a choice between action and inactivity in regard to two stimuli which are given in irregular order the time is considerably increased. If, for example,

[1] σ is a conventional sign to indicate the thousandth part of a second.

the subject is instructed to react with the hand when a loud sound is given and not to react when a sound is of little intensity the time for this "choice" reaction will be about 200 σ. If the stimuli are more numerous and the reaction is made to only one of the stimuli, the "choice" reaction may take as long as 400 σ.

When reactions are to be made to a number of stimuli and the reaction is to vary in accordance with the stimulus the time of this complex "association" reaction is greater than that for the choice reaction. For example, if the subject is instructed to react with the thumb of the right hand when the letter *a* is shown, with the first finger for *b*, with the middle finger for *c*, with the ring finger for *d*, and with the little finger for *e*, the association reactions in an experiment of this character average from 300 σ to 600 σ.

Other association reactions may be performed in which the stimuli, although definite in themselves, are not a series and in which any particular stimulus is not definitely known beforehand by the subject. When the stimulus is received, it must, therefore, be apprehended; it must be compared also with other similar stimuli; a decision must be reached and the appropriate movement must be performed. For example, if the subject be compelled to react by an appropriate movement of a vocal apparatus to such stimuli as, "In what country is Geneva?" or "What language did Bacon use?" the time will be found to approximate 500 σ. When the mental processes become more complex, the time increases still more. To the stimulus, "Which is healthier, dancing or swimming?" or "Which is the most important river in Germany?" a reaction or response is made although the definite reaction has not been previously worked out by the subject and consequently is not closely associated with the particular stimulus. Because there is a comparison and a judgment involved in tests of this character the reaction times may exceed one second.

Certain stimuli which affect consciousness in a particular manner produce reactions in not less than 5 seconds, and certain other complex stimuli or series of stimuli may not produce an appropriate reaction for weeks or months. During the interval between the primary stimulus and the appropriate reaction many other stimuli are received which help to determine or to limit the mode of activity in response to the original stimulus. These extra

stimuli may be due to partial reactions of the subject to the primary stimulus, and these continue to produce other physiological reactions until the activity appropriate to the original stimulus is produced. The question "Which was the better general, Wellington or Bonaparte?" may lead in a second or two to a reaction or response "Bonaparte." On the other hand, it may not lead to this response but may at first produce a reaction which is only a part of or has only a bearing upon the ultimate reaction. For example, it may lead to the taking down of several volumes of an encyclopedia, secondly to a reading of certain articles therein and the original stimulus becomes more complex because of these secondary activities. References found in these articles may lead to the consideration of other publications or to conversations with people who have studied this particular topic. Eventually, an appropriate reaction of the individual may result. This result may take the form of an article in a book, and it is commonly said to be due to study. The more complex the situations or stimuli are, the longer it takes for the individual to decide and to react to these stimuli.

If we take for consideration a series of progressively more elaborate reactions, it is possible to estimate the amount of time for the performance of cerebral acts which accompany the complex mental processes. If it takes 200 σ for a simple speech reaction to a definite stimulus, and 450 σ for a "choice" reaction and 600 σ for an "association" reaction to similar stimuli, it is apparent that the time taken for the mental processes are respectively 250 σ and 400 σ for "choice" and "association." Similar estimations may be made of the time of a number of different mental processes, if we have care that the results are obtained with comparative material.

Tests of Time of Mental Processes

Two series of tests are suggested in this chapter for the purpose of determining the time of certain mental processes. Either one or both series may be used, for each has certain elements of difference from the other, and the advantages of each will be apparent to the experimenter. The first series (four tests: (*a*), (*b*), (*c*), (*d*)) is to be performed with cards, the second (five tests: (*e*), (*f*), (*g*), (*h*), (*i*)) with special forms.

An accurate measurement of the simple reaction time can be made only by the use of elaborate apparatus, by timed exposures, and by tedious adjustments and calculations which are prohibitive for clinical purposes. The accurate measurement of the times of the more complex mental processes also requires a greater amount of apparatus than can be profitably used in clinical work and more cooperation than can be usually obtained from the subjects. The tests which are suggested are, therefore, simple and, although not always specific for the mental states or processes to be tested, they are sufficiently accurate for diagnosis and for the estimation of the time of simple and complex mental states.

(*a*) *Simple Reaction Time.*—Give the subject a pack of 50 or 100 well-shuffled cards and instruct him to deal these out one at a time as rapidly as possible. Measure with a stop-watch the time for the dealing of the total number and calculate the average time for the handling and dealing of one card. In this experiment there are successive stimuli to which the subject must react in a definite, consciously determined manner and although the serial stimuli give a condition somewhat different from single stimuli the results of the test are to be taken as representative of those with single stimuli and more elaborate apparatus. It has been found that the normal time for dealing 50 cards as rapidly as possible varies from 10 to 15 seconds, giving the average simple reaction from 200 σ to 300 σ. This, it will be noted, is in excess of the simple reaction time measured by the chronoscope.

(*b*) *Time of Discrimination and Movement.*—In this test the well-shuffled cards are given to the subject face upwards, and he is instructed to deal them as rapidly as possible into two heaps, placing all the black cards in one and all the red cards in the second heap. In this test, as will be seen, there must be a discrimination of the colors and at the same time there must be the association of the proper movements with the appropriate color. It will be appreciated that in this test movements are required similar to those in the simple reaction test, and that there have been added certain elements to make this test somewhat more complex. By subtracting the time for the simple reaction from that of these more complex ones the average time for discrimination may be calculated. The normal time for the performance of

the test varies from 17 to 25 seconds, and the discrimination time may be said to average 150 σ to 200 σ.

(*c*) *The Time of Discrimination and Association.*—The same pack of cards is used. These are well shuffled and presented to the subject who is instructed to deal them into four heaps in accordance with the forms. All of the clubs should be put in one place, all of the spades in another, the diamonds in a third, and the hearts in a fourth. Here there must be a discrimination of four things instead of two as in the preceding test (*b*) and the time for the whole test is correspondingly increased. The normal time for the distribution according to the four suits takes from 20 to 35 seconds, *i. e.*, an average time of 400 σ to 700 σ each. The average time for the extra discrimination and adjustment is therefore 200 σ to 400 σ beyond the simple reaction time and 50 σ to 200 σ beyond the time for the discrimination of the two colors.

(*d*) *Time of Discrimination and Association.*—Further complexity may be introduced by having the cards dealt by the subject into heaps according to their numerical values, instead of colors and suits. In this test all the aces should be placed together, all the deuces, all the trays, etc., by themselves. There are thirteen discriminations to be made, instead of four, as in experiment (*c*), and this greater complexity increases the time for the distribution of 50 cards to 50 or 75 seconds, an average of 1,000 σ to 1,500 σ for each discrimination, association and movement.

(*e*) *Simple Reaction Time.*—A test which may take the place of the distribution of cards has already been described in the section on the speed of movement (p. 39). The subject is given a sheet of paper and pencil and instructed to make separate marks on this sheet as rapidly as possible in lines running to and fro. This may be continued for 10, 20, or 30 seconds, and the average time for a single mark or reaction may then be calculated. To make the test directly comparable with others in this series, it is suggested that the subject be instructed to make 100 marks on the paper and the time for this number be determined. The average gives the single reaction time.

(*f*) *Time of Discrimination and Movement.*—A sheet of cross section paper (4 to the inch) and a pencil are presented to the subject, who is instructed to make as rapidly as possible a mark in each one of 100 squares. The subject is instructed that no mistakes are to be allowed but that the mark must be put inside

the square.[2] It will be seen that this test involves movements similar to those in test (*e*), and that there is added the requirement of discrimination of the sizes and locations of the squares. The time for discrimination and movement is to be recorded, and the difference between this and the reaction time (test (*e*)) gives the time of discrimination.

(*g*) *Time of Discrimination and Movement.*—The subject is presented with a pencil and a form sheet containing a series of letters or digits and instructed to cross out, as rapidly as possible, all the A's or all the H's or all the 6's or all the 3's, as the experimenter wishes. In the forms which are illustrated (figures 21–23) there are 25 of each letter and digit, so that the time for the

4	3	8	5	9	3	4	5	2	4	7	6	
5	8	7	2	3	6	6	3	7	6	3	9	3
8	6	3	7	7	9	3	5	6	4	8	8	
9	4	6	8	9	4	7	9	7	8	4	8	9
5	9	8	5	3	2	8	6	9	8	3	9	
7	2	8	7	6	4	3	8	5	8	5	7	9
2	5	7	2	8	2	8	7	9	4	3	7	
6	2	8	3	7	9	7	5	3	5	5	6	2
7	9	4	9	2	2	4	8	4	2	3	7	
4	5	7	6	3	9	3	6	5	5	9	5	4
7	2	6	2	9	9	4	2	9	7	8	7	
2	8	3	5	6	4	7	8	7	2	4	3	8
2	6	6	5	9	4	5	8	8	3	2	4	
8	2	6	2	3	3	4	4	6	2	5	2	3
4	5	2	5	7	5	4	6	4	3	3	9	
5	9	6	2	9	5	6	6	4	9	6	6	7

FIG. 21. Digit form for testing the time of mental processes.

performance of the whole operation must be divided by that number. Here there is a discrimination of 200 letters or digits and the performance of 25 movements. The normal time for tests of this character varies from 35 to 60 sec., and each digit or letter takes, therefore, approximately 1.4 to 2.4 sec. From the

[2] In a previous test on accuracy of movement (p. 46) a similar test is used, but in the former test mistakes are permitted and are used for determining accuracy. Here the subject is not permitted to make mistakes, *i. e.*, marks in other squares.

G D R L S D G L A G P O
L R P A D O O D P O D S D
R O D P P S D L O G R R
S G O R S G P S P R G R S
L S R L D A R O S R D S
P A R P O G D R L R L P S
A L P A R A R P S G D P
O A R D P S P L D L L O A
P S G S A A G R G A D P
G L P O D S D O L L S L G
P A O A S S G A S P R P
A R D L O G P R P A G D R
A O O L S G L R R D A G
R A O A D D G G O A L A D
G L A L P L G O G D D S
L S O A S L O O G S O O P

FIG. 22. Letter form for testing the time of mental processes.

H C W I Y C H I B H T N
I W T B C N N C T N C Y C
W N C T T Y C I N H W W
Y H N W Y H T Y T W H W Y
I Y W I C B W N Y W C Y
T B W T N H C W I W I T Y
B I T B W B W T Y H C T
N B W C T Y T I C I I N B
T Y H Y B B H W H B C T
H I T N C Y C N I I Y I H
T B N B Y Y H B Y T W T
B W C I N H T W T B H C W
B N N I Y H I W W C B H
W B N B C C H H N B I B C
H I B I T I H N H C C Y
I Y N B Y I N N H Y N N T

FIG. 23. Letter form for testing the time of mental processes.

average time there may be subtracted the average time for the performance of a movement (test (*e*)) and the average time for the discrimination is thus determined.

(*h*) *Time of Discrimination, Association and Movement.*— The forms used in the above test may be utilized to test more complex processes, the subject being instructed to mark as rapidly as possible all the 6's and 9's, or all the A's and L's, or all the H's and T's or other combinations selected by the experimenter.

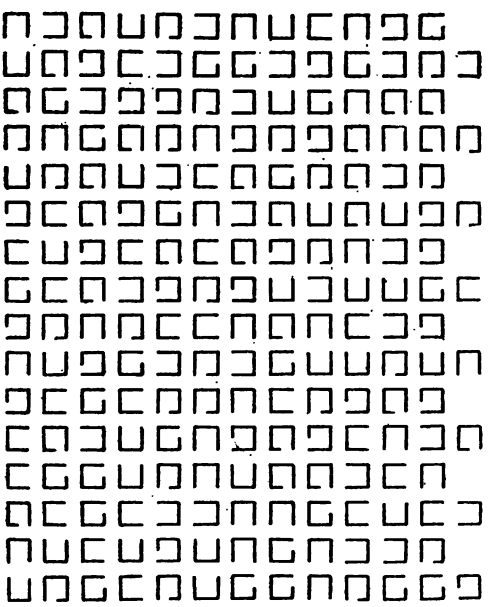

FIG. 24. Form for testing the time of mental processes.

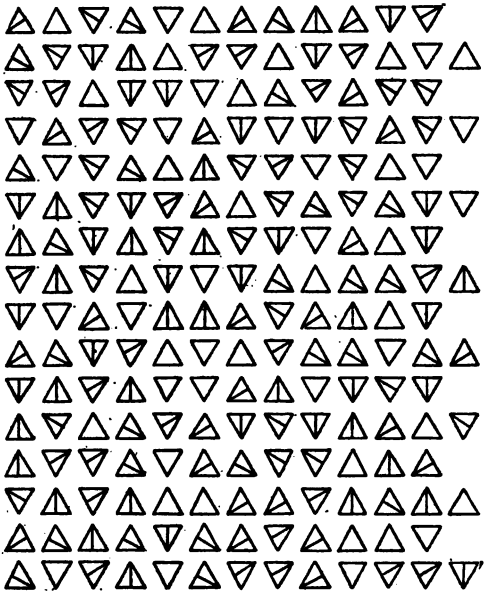

FIG. 25. Form for testing the time of mental processes.

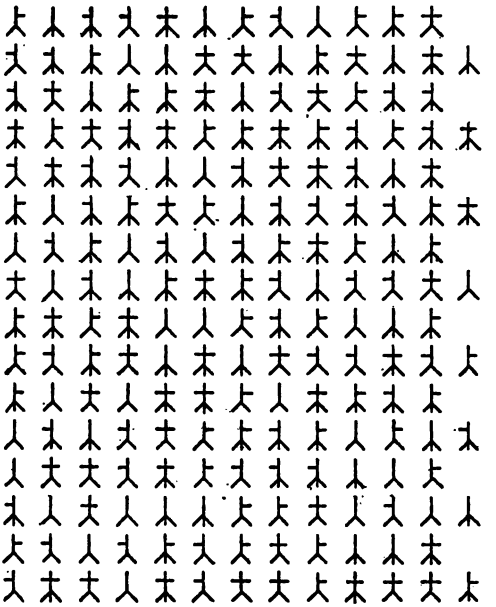

FIG. 26. Form for testing the time of mental processes.

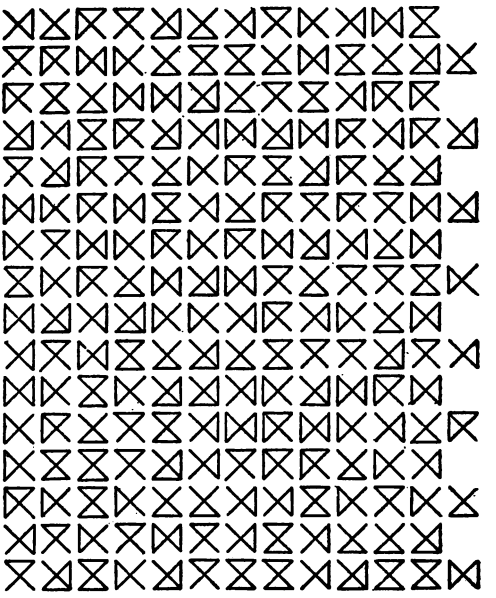

FIG. 27. Form for testing the time of mental processes.

(*i*) *Time of Discrimination, Association and Movement.*— A greater complexity is introduced into tests of this character if the forms be unfamiliar ones, such as those illustrated in Figs. 24–27. One of the forms is selected by the experimenter and the subject is instructed to mark all (25) of these on the sheet. The time for the performance of this test is greater than that of the other tests in this series on account of the similarity in appearance of many of the figures on each of the sheets,[3] and because of the unfamiliarity of the subject with figures of this character.

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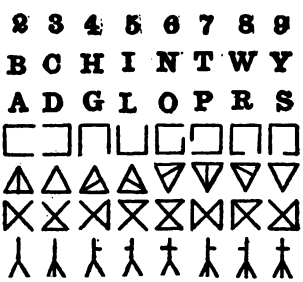
See also references 2, 8, 11 (Chap. I), 111 (Chap. VII) and 147 (Chap. XII).

[3] It is to be noticed that each form sheet, although apparently quite different from all the others, is similar in the relative arrangement of the letters, digits and forms. The following key shows the comparative forms:



CHAPTER X

GENERAL INTELLIGENCE

There are many mental processes which can not be grouped under the headings which have been considered so far, and it has been a custom for psychiatrists to deal with these mental states under the heading of general intelligence. Here we deal with the more complex processes which require comparison and judgment, and perhaps a certain amount of intuition. Tests for the estimation of the general intelligence of the individual are numerous. There are those in which ideas are enumerated, and others which tend to bring out the way in which the individual may deal with situations. The Ebbinghaus tests (completion method) were, for example, primarily used for the determination of general intelligence and they are still used to a great extent for this purpose although they have also been used for tests of apperception ability. The following tests are suggested for the purpose of determining in collections of cases the way in which individuals deal with situations, the general amount of information which they possess, etc. The calculation of the results of these tests is difficult, at times impossible, and it should be remembered that at times the tests give only information as to the memory of the individual.

(*a*) *Knowledge of Common Things.*—A number of tests may be made to determine the range of information which the individual possesses. Questions are to be asked such as:

> Name 5 different kinds of flowers; trees; bushes; cloth for making clothing; grain; precious stones; fruits; and vegetables. Name 5 colors; 3 ways of lighting; 5 things made of iron; 5 made of brass; 5 of wood; 5 parts of the body; 5 things to wear; names of 5 countries; 5 planets; 3 prominent scientific men or inventors.

Answers to these questions, it will be seen, will be given in accordance with the previous training of the individual; one who has been brought up in the country will perhaps have no difficulty in naming ten different kinds of flowers, grain, trees, etc., but

may have no knowledge of those things which are made of iron, brass, and the names of precious stones. Questions should be devised in accordance with the previous condition of the individual who is being tested, and sexual differences must be remembered. The following questions give some indication of the general intelligence of the subject and his knowledge of common things:

What date comes before the first of March? the first of July? the first of April? etc.

What does it cost to send a letter to Germany? to England? to New York? etc.

How far is it to San Francisco? to France? to Morocco? etc.

(*b*) *Ziehen Test.*—For the determination of the ability of discrimination, comparison and description, the test which has been suggested by Ziehen is useful. This is a test in which the subject is asked to differentiate definite sorts of animals or different processes or things. For example, the subject is asked:

What is the difference between a bird and a butterfly; between a horse and an ox; between wool and linen; dwarf and child; lie and mistake; water and ice; pencil and pen; tree and bush; cigar and cigarette; round and oval; square and oblong; vegetable and fruit; running and walking; carpenter and cabinet maker; owner and partner; cloud and mist; muddy and opaque; silent and mute; etc.

In estimating the ability of the subject, the experimenter must differentiate between a limited vocabulary and a poor ability.

(*c*) *Use of Collective Terms.*—A similar test may be made by having the subject give the general name of a number of things with unlike qualities.

What sort of animals would you call horses, cows, pigs and sheep? lions, tigers and elephants? What would you call chairs, tables and carpets? apples, pears and bananas? shoes, collars and coat? crow, eagle and hawk? bricks, mortar and cement? carrots, onions and tomatoes? dime, cent and dollar?

(*d*) *Masselon Test.*[1]—In this test three or more words are

[1] It should be mentioned that a test like that which psychiatrists call the "Masselon" test was used by Binet in 1896 and in 1902, and by Sharpe in 1899 before Masselon applied it to the abnormal.

given which are associated, and these are to be grouped by the subject into a sensible phrase or sentence. The subject is instructed to take the words which are given and to join them with conjunctions, verbs, etc., but not necessarily in the order in which they are given to him. For example, pen, ink, letter, would make the following sentence—I dipped my pen into the ink and wrote a letter, or, pen and ink are necessary to write a letter, or, there are pens, inks and letters on my desk, etc. The following lists are suggested.

Pipe, match, smoke.
Tree, leaf, flower.
Work, wages, week.
Lightning, day, rain.
Hunter, dog, gun, rabbit.
Clouds, moon, stars, night.
Sick, doctor, nurse, hospital.
Man, wood, coal, stove, dinner.
Needle, thread, button, vest.
Money, store, street, beggar, car.

(*e*) *Completion Tests.*—Tests similar to those originally devised by Ebbinghaus may be made by having the subject fill in individual letters of words to see in what way he may grasp the meaning of the words which are presented. In these words

(p)encil.	do(ll)ar.	pon(y).
(g)reen.	wa(t)er.	elbo(w).
(f)atigue.	le(tt)er.	ric(e).
(r)ush.	dim(p)le.	brea(d).
(m)aple.	ope(r)a.	ivor(y).
(c)oal.	cou(p)on.	proo(f).
(h)at.	ca(m)era.	stam(p).
(g)lass.	c(l)ub.	stea(m).
(p)aper.	fa(v)or.	fac(t).
(b)rush.	sca(l)es.	victo(r).

a space is left for each letter omitted. If the subject does not get the words correctly as they are supposed to be but makes other substitutions which have sense, the results should be considered correct. This test presupposes an ability to spell, which, it should not be necessary to state, is sometimes lacking in subjects otherwise intelligent.

(*f*) *Reading Backwards and Upside Down.*—A test for gen-

eral intelligence is the presentation to the subject of printed matter which is set up backwards, for example.

.ralucidneprep
.noitacifislaf
.thgirpu klaW
.flesruoy htiw tnetsisnocni era uoY
?noitacav ruoy ekat ot tcepxe uoy od nehW
.eldi eht htiw etaicossa ton oD
?ereh neeb uoy evah gnol woH

Here one would write for these sentences as follows:

perpendicular.
falsification.
Walk upright.
You are inconsistent with yourself.
When do you expect to take your vacation?
Do not associate with the idle.
How long have you been here?

A similar test may be made by presenting to the subject a sheet of paper with the printing upside down and have the subject read with the paper in this position. Occasionally subjects are found who read in this way very readily, but most subjects require considerable time in which to read sentences or phrases when presented in this way.

(*g*) *Meanings of Pictures.*—Complex material may also be presented to the subject and he then be asked to form a judgment regarding the material which is presented. In this test pictures are shown and he is asked to describe not the individual elements but the meaning of the pictures as a whole. The following pictures are suggested for this work:[2] the illustrations in the Jingleman Book;[3] the Disputed Case;[4] Washington and Sally;[5] and The Orphan's Prayer.[6]

(*h*) *Finckh Test.*—Another simple test is that of Finckh in

[2] Other illustrations have been used by me in the examination of the insane, but since these are also used for abnormal children and normal individuals they are recommended because of the possibility of comparing results.

[3] Also Leutemann's Types of Nations (E. Steiger and Co., New York).

[4] No. 1,235 of the Taber-Prang Art Company Collection.

[5] No. 699 of the Taber-Prang Art Company Collection.

[6] No. 1,207 of the Taber-Prang Art Company Collection.

which the subject is asked to explain the meaning of simple mottoes or proverbs.

The early bird catches the worm.
A rolling stone gathers no moss.
Set a thief to catch a thief.
Burn the candle at both ends.
A stitch in time saves nine.
No man is a hero to his valet.
Who spareth the rod hateth his child.
All that glitters is not gold.

(*i*) *Logical Tests.*—In addition to these, logical problems may be presented to the subject for his consideration. Although comparatively few people have had training in formal logic, most normal people of average intelligence are able to decide that a simple proposition is correct or incorrect even though the reason for the correctness or incorrectness be unknown. In this way the subject is presented with easy logical propositions, to the conclusions of which he may accede if the premises be correct. If, on the other hand, the premises be incorrect or the form be incorrect, and the conclusions consequently incorrect, normal people hesitate to accept the conclusions and often the conclusion is doubted. The following logical propositions are suggested:

All men are fallible; women are not men; therefore women are not fallible.

All Europeans are Caucasians; Caucasians are white; therefore all Europeans are white.

All Parisians are French; no Chinese are Parisians; therefore no Chinese are French.

All roses are beautiful; lilies are not roses; therefore lilies are not beautiful.

Nothing is better than wisdom; dry bread is better than nothing; therefore dry bread is better than wisdom.

None but savages were in America when it was discovered; the Hottentots are savages and must therefore have been in America when it was discovered.

Repentence is a good quality; wicked men abound in repentance; therefore abound in what is good.

The object of war is to promote peace; therefore soldiers are the best peace-makers.

(*k*) *The Appreciation of Absurdities.*—A simple test may be made by having the subject give his opinion regarding one or more of the following absurd statements:

An unfortunate bicycle rider broke his head and died instantly; he was picked up and carried to the hospital; they think he will not recover.

The engineer said that the more cars he had on his train, the faster he could go.

We met a man who was finely dressed; he was walking along the street with his hands in his pockets and twirling his cane.

Some one said "If I kill myself in desperation some day, I shall not choose Friday to do it, because Friday brings bad luck."

When the peaches were ripe they bought canned fruit to eat, so that the fresh fruit could be canned for winter and spring use.

The general with his hands behind his back paced the floor, reading a newspaper.

There was found in the park to day the body of an unfortunate young girl, frightfully mutilated, and chopped into 18 pieces; it is said that she committed suicide.

The advocates of universal peace will go to all sorts of extremes to get their views accepted, for they fight those who dare to disagree with them.

(*l*) *Word-building Test.*—This is a test similar to that of Ebbinghaus, the subject being presented with a number of letters which are to be combined into words, each letter to be used only the number of times it occurs in the sample, and the words to be sensible and not nonsense syllables. All the letters are not necessarily used in the making of the words, at times only two or three are needed. The letters used by Whipple in this test are as follows:

(1) a, e, o, b, m, t.
(2) e, a, i, r, l, p.

The subject is given three minutes in which to construct the words and the number is counted. Although there are 70 possible combinations of the first set of letters, only about 40 of these words are in fairly common use, and of the 105 possible combinations with the second set only about 50 are common.

(*m*) *Vocabulary Test.*—This test is made to discover the words, the meaning of which a subject knows. This test has been used for determining the range of intelligence, but it is difficult to interpret on account of the fact that the groups of abnormal subjects are not even reasonably homogeneous, since education, previous occupation, and other factors are so different. A list of rather unusual words is prepared and the subject is asked to

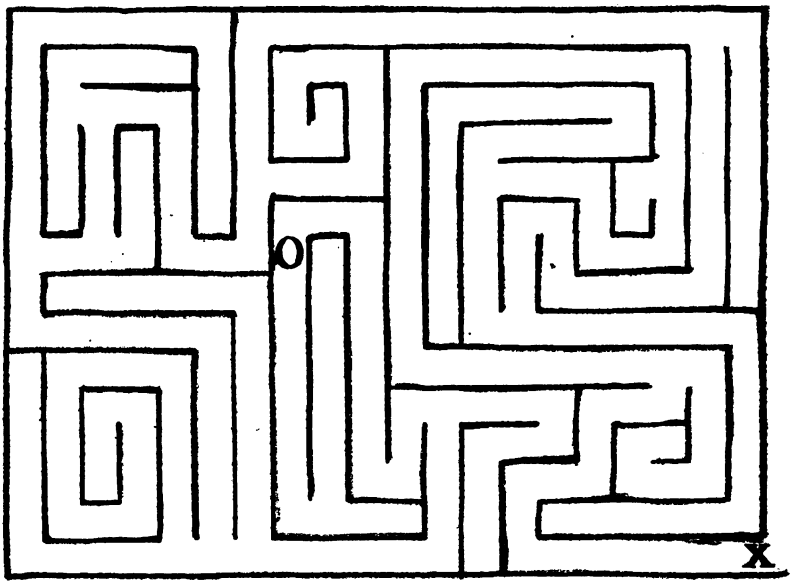


FIG. 28. Simple maze. *O*, starting point; *X*, goal.

define or to use in its proper way by placing in a sentence each of the words on the list.

(*n*) *Maze Test.*—An excellent test for the determination of the manner in which an individual reacts to rather complex situations is one in which a maze is used. Figures 28 and 29 illustrate two of these, Fig. 29 being somewhat more complex than Fig. 28. A pencil and a sheet of paper bearing one of these diagrams is placed before the subject and he is instructed to start his pencil at the place marked with an O and to work his way out from that point to the point marked X without crossing any of the lines and if possible without retracing steps. The pencil should not be taken from the paper once the test is begun

and if any retracing must be done the path must be indicated in pencil by the subject. This test is, as has been said, a good one for it is found that certain subjects will traverse spaces many times although it should be evident to them that after a line

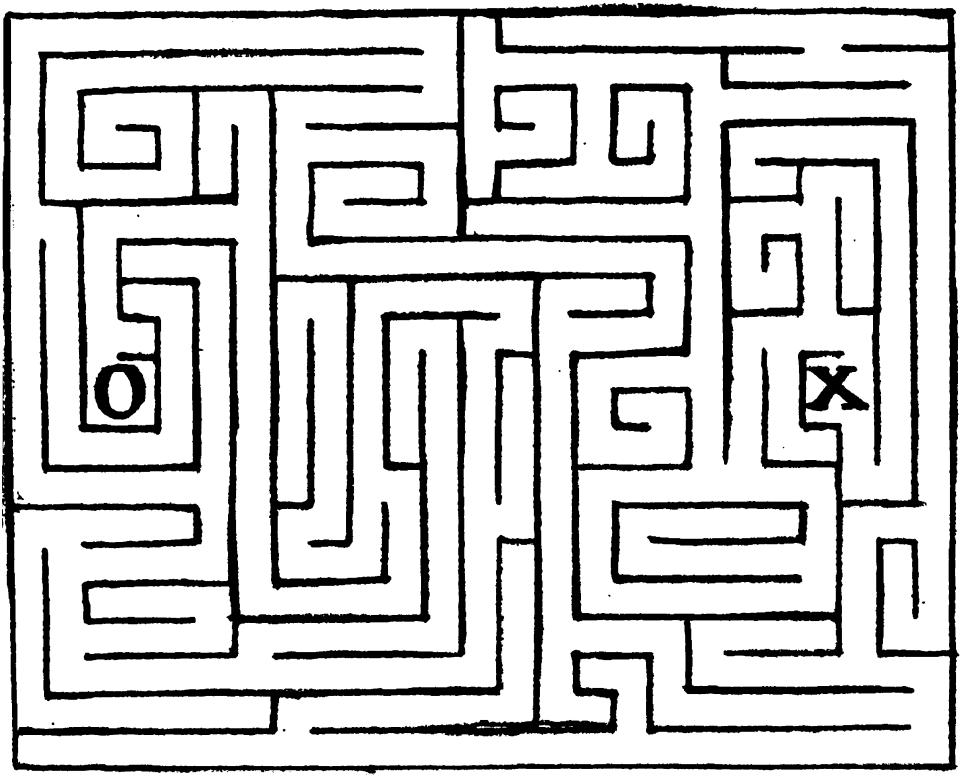


FIG. 29. Complex maze. *O*, starting point; *X*, goal.

has been made and retraced it indicates some kind of a block. The time for the successful completion of the task is to be noted for it gives an indication of how readily the problem is solved.

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See also references 19 (Chap. I), 81 (Chap. V), 115 (Chap. VIII) and 147 (Chap. XII).

CHAPTER XI

SCHEME OF GENERAL EXAMINATION

Parts I, II, and III are usually obtained from a relation or close frient of the patient, and the data are to be compared with the answers of the patient to similar inquiries, Part VI. The special tests are not included in this scheme, for they are taken up in more detail in the chapters devoted to these subjects.

I. Family History

Parents: Dates of birth and death; causes of death; occupations, etc. Were parents of patient related, or did they differ greatly in age?

Mental Characteristics: What were their mental characteristics (*i. e.,* disposition, temperament, etc.)? Did either have extraordinary gifts, one-sided talents, or abnormal traits?

Nervous and Mental Disorders: Was either nervous? What were the symptoms? Did either have convulsions, periodical headaches, migraine, or hemicrania? Was either neurasthenic? or ever insane? or at any time a patient in a hospital for nervous or mental diseases? Where? When, and how long did she or he remain? What age at the time? How long after or before the patient was born? Did either have any other nervous disorders (tics, paralyzed, aphasia, etc.)?

Other Diseases: Did either have constitutional diseases (syphilis, tuberculosis, diabetes, arthritis, etc.)?

Alcohol: Was either addicted to the use of alcohol? How much was taken in a day, week, month, etc.? How long was it taken (years)? What was the result? Did either have delirium tremens?

Crime and Suicide: Was either a criminal? What crimes were committed? Was he or she punished by law? What was the punishment? Did either commit or attempt suicide? Under what circumstances?

Defects of Siblings:[1] Dates of birth, death; causes of death; occupations, etc. Were the siblings of either congenitally deformed? blind? deaf? or dumb? Did siblings of either have convulsions or other nervous diseases? Were any insane, or patients at hospitals for nervous or mental diseases?

Grandparents: If there appears to be an hereditary taint, get, as in the above questions, details for both the maternal and the paternal grandparents.

Siblings of Patient: Are or were there siblings of patient? Give in order (noting male and female), and get ages if living, or ages at and causes of death, miscarriages, premature or still births, etc. Inquire regarding nervous and mental diseases, occupations and their general success in life.

II. History of Patient

Full Name and Age: (in years and months).

Address: What is the address of the patient? How long has he lived there?

Occupation: What is the business, profession, or occupation of the patient? How long has he been thus occupied? What previous occupations had he had? Get the details of how long he has retained each position, how successful he was in each one, and why he left.

Birth and Infancy: At the time of the birth of the patient did the mother have a difficult labor? Were instruments used? What was the cause of the obstetrical difficulty? Was the patient injured at the time of birth? Get details of any abnormalities of infancy, *e. g.,* growth.

Early Childhood: Had the patient convulsions in childhood? How old was he or she when these began? How many years did they continue? How long was each seizure? Give details regarding their character (*e. g.,* loss of consciousness; local or general; how brought on; etc.). Had the patient rickets? What other diseases in childhood did the patient have? When and with what result? When did he learn to walk? When did he learn to talk?

School: When did he first attend school? Where did he go?

[1] Siblings is a word invented by Pearson to denote children of the same parents.

In school was he bright, average, or stupid? How long did he attend school? Was he always promoted from class to class? If not, why not? Did he associate with the other children? Was he mischievous, quiet, popular, studious, lazy, etc.?

Injuries and Diseases in Later Life: Has the patient had any head injuries or convulsions (*i. e.,* beyond what were mentioned in answer to questions above)? Has he had gonorrhœa? Has he had syphilis? What treatment for them did he receive, and what were the after effects? What other diseases has the patient had? After effects?

Alcohol: Has patient taken alcohol in any form (beer, wine, whiskey, tonic medicines, etc.)? How much of each has he taken by the day, week or month? How long has he been taking alcohol? Has he become drunk? Has he ever had delirium tremens? Has the alcohol made him pleasant or disagreeable?

Other Habits: Has the patient taken drugs, such as cocaine, morphine, opium, or any others for long periods of time? Has he used tobacco? Did he smoke, chew, or snuff? How much tobacco did he use in a day, in a week? What were the sexual habits of the patient, before and after marriage?

Marriage and Children: Is or has the patient been married? When was he married? Is the wife (or husband) still living? How many times has he been married? Has married life been happy? If not, why not? Has the patient or wife any gynecological or menstrual difficulties? When did catamenia begin? When end? Regularity? Has the patient had abortions or miscarriages? Get the details (how often, when, and how they were brought about). How many children has the patient had? Give them in order, noting sexes, ages, nervous and mental diseases, etc. Get details of the mental characteristics of the children, especially noting symptoms of retardation (imbecility), precociousness, etc.

Previous Attacks: Had the patient similar attacks before? What were the symptoms? How long did the condition last? Did he go to a hospital for nervous or mental diseases? If he has not had similar attacks before, inquire if he has had periods of depression or of exaltation, how long these lasted, what was done during these attacks, etc., or, if there were periods of mental "breakdown," etc. Get any further details about the disposition of the patient; how he got on with his companions; whether or

not he was sociable, moody, inclined to look on the bright or the dark side of life, etc.

Crimes and Misdemeanors: Has patient been arrested? When? For what? With what result? Has he come in contact with legal officers in other ways, *e. g.*, suits at law? Get details.

Mental Make-up: What has been the general disposition—(brooding, cool, deliberate, depressed, excitable, explosive, flighty, forlorn, gay, genial, gentle, gloomy, hasty, industrious, introspective, irascible, lazy, lonely, moderate, moody, morose, optimistic, pugnacious, querulous, quiet, religious, resentful, retiring, sedate, serious, slow, solemn, sociable, studious, tranquil, unsociable, etc.)? Has this changed from time to time? Has the change appeared to be periodical?

III. History of the Present Illness

Cause and Onset: Did the present illness come on as the result of an accident or disease? Did the patient have a physical or mental shock? Has he been under extraordinary strain for some time? Is the present attack thought to be due to excess of any sort? Specify. Did the attack come on gradually or suddenly?

General Physical and Mental Changes: Have there been character changes in the patient? Has he been agreeable to his wife (her husband) and children? to friends and neighbors? Has he appeared to be dazed? or quiet? or restless? Has he been excited? Has he been tidy in feeding and in his other habits? Has he spoken much or little? or has he been dumb? Has he slept well? regularly? How many hours has he slept each night? Has he eaten well? or little? Has he had a perverse or abnormal appetite? Has he taken his meals regularly? Does he give any explanation for his poor appetite? or his refusal to eat food? What was the patient's weight before the illness began? Has he been tremulous in hands or in speech? Has he become bald or has the hair whitened? Note other changes in the physical condition of the patient since the beginning of the illness.

Emotional Condition: Has the patient been depressed? or unduly joyful? or apathetic? Has he been passionate? or inclined to anger? or threatening?

Hallucinations and Delusions: Has he heard imaginary sounds or voices? What have they said? Did he go through the house

looking under the beds and the furniture, and in the cupboards? Did he listen in corners or at the walls? Did he look at definite points for some time? Has he had ideas of persecution? or of grandeur? Do the delusions change?

Suicide and Homicide: Has patient made attempts at suicide? at homicide? What were the exciting causes?

Intellectual and Memory Defects: Has he shown any intellectual defect? Has he recognized his friends and relations? Does he mistake persons? Has he kept track of the days of the week and of the month? Has he known where he has been?

Moral and Legal Laxness: Has the patient offended against the law? against morality? How did he so offend and with what result?

Insight: Has he understood that he has been mentally different from his normal condition? Does he appreciate the nature of his disorder?

Miscellaneous: Has the patient any indications of sterotopy? or of catalepsy? of apparent playfulness? of impulsive actions?

Add any other information that the informant can give regarding mental changes in the patient.

IV. General Observation of the Patient

Is he in bed? about the ward? on parole?

Facial Expression: Does the patient look sad? fearful? gay? hostile? suspicious? visionary? expressionless? intent? arrogant? sleepy? cyanotic? demented?

Movements: Are there movements of the body? of the head? of the face? Is there Schnauz-krampf? Are there rythmic quiverings of the mouth? Are there wrinklings of the forehead? Are there stereotyped movements? Does the patient walk straight and to some purpose? Walk irregularly or go from one thing to another? Does he go slowly or quickly?

Appearance and Demeanor: How does he carry his hands? Is his hair tidy or unkempt? Is he fully dressed? half dressed? or naked? Is his clothing well kept? Does it show that he has been untidy in feeding and drinking? Do the clothes fit the patient?

Mental Observations: Did he voluntarily complain of being brought to an institution, of ill-being or ill-treatment, or speak of

his delusions or his feelings? Was he coherent? Was it difficult to keep him on the line of questioning? Did he cooperate in the mental and physical examinations, or did he raise objections to them? How did he receive the visit of the physicians?

V. Neurological Examination

Stigmata of Degeneration: Bodily anomalies.

Muscular System: Size (atrophies and hypertrophies); firmness; activity.

Voluntary Movements: Activity, rapidity, accuracy; force (especially pareses and paralyses); limitations (rigidities, contractures, etc.). See chapter III.

Involuntary Movements: Rigidities; tremor, intention and at rest; quick (over 4 a second) or slow (4 or less a second), general or localized (of large groups, of small groups or of parts, *i. e.,* fibrillary); spasms (tonic or clonic); convulsions; tics; etc.

Reflexes: Tendon; skin; periosteal; organic; knee kick; tendo Achillis, contra-lateral adductor, plantar (2), abdominal (superior, median, inferior), interscapular, triceps, ulnar, radial, jaw (masseter), vaso-motor (dermatographia, flushing, pallor, etc.), eye (corneal, sympathetic, direct and consensual light, accommodation), pharyngeal. Time (slow, quick); area (localized, general); extent (decrease, increase); character (*i. e.,* abnormality, *e. g.,* Babinski phenomenon, ankle, wrist, or patellar clonus).

Sensitiveness of Nerve Trunks: Tender areas (especially vertebræ, breast, ovarian); localization (referred pains, etc.).

Coordination: Finger-nose, finger-finger, fingers-thumb, knee-heel, station (eyes open and closed, one and both feet), gait (ataxic, paraplegic, hemiplegic, spastic, staggering, propulsive).

Cranial Nerves: I. Smell; solutions. II. Vision; acuity, fields (hemiopia, contractions), color vision, entoptic phenomena, ophthalmoscopic examination. III, IV, VI. Eye movements (all directions); nystagmus, horizontal, vertical, rotary; heterophoria; diplopia; ptosis; pupils (size, outline, reflexes). V. Taste; solutions. Chewing movements. Corneal reflex. VII. Facial symmetry and motility (whistling, showing teeth, etc.). VIII. Hearing; acute, sub-acute, or deaf; test of air and bone conduction; high and low tones. IX, X, XI. Swallowing; pharyngeal reflex. XII. Protrusion of tongue.

Other Sensations: Touch (threshold, localization, double point threshold); pressure (discrimination); pain (threshold, localization); temperature (hotness, warmth, coolness, and cold, difference thresholds); stereognostic sense (sense of form); joint and muscle sense (passive and active movements); organic sensations (hunger, thirst, fatigue, sexual, desire for urination and defecation, feeling of reality). Anesthesia (or analgesia or thermoanesthesia); hyperesthesia; hypesthesia; paresthesia, etc.

VI. Mental Examination

General Memory and Orientation: What is your full name? Where were you born? Where do you live? What is your age? In what year were you born? What year is this? What month is this? What day of the month? What day of the week? (If the answers to the foregoing questions are not consistent, try to get the patient to explain the discrepancy.) What city is this? What place is this? How far from your home is this? When did you come here? How long have you been here? Who brought you here? How did you come? What did you do when you arrived? Whom did you see when you arrived? Did you ever see me before? What is my name? What is his (other physician or nurse) name? When did you get up this morning? Did you have breakfast? What did you have? Did you have dinner? Did you have supper? What did you have for these meals? Has any one visited you? Who was it? Is he a relative? When did he come? How long did he stay? Why did he come?

General Understanding and Insight: What kind of a place is this? What kinds of people are here? Who are they (patients)? Who are they (nurses and attendants)? Who am I, who are we (physicians)? Why are you here? Did you want to come? Is there anything wrong with you? Are you sick? Do you feel quite well? Is your mind all right?

Special Memory—Family: What are the names of your parents? Are they living? Where do they live? What was the name of your mother before she was married? How many brothers and sisters did you have? Give their names. Are they all living? Which ones are dead? Of what did they die? How old were they at time of death? Where do those living live? What do they do?

School: Where did you first go to school? What age were you at that time? What other schools did you attend? Give the names of some of your teachers? What did you learn in school, *i. e.,* what subjects did you have, and how far did you get with them? Did you have any favorite subjects in your school work? Which were the hardest?

Occupations: What is your occupation? When did you first go to work? What age were you? What other work have you done? Give the dates and the time for each position that you have held, and tell why you left each place.

Marriage and Children: Are you married? When were you married? How long ago is that? What was your wife's (or your) maiden name? Have you children? When were they born? How many are now living? How old are those now living? What are their names? Where do they live? How many are dead? How old were those that died? Of what diseases did they die? Has your wife (or you) had miscarriages or abortions?

Diseases: What diseases did you have as a child? Did you ever have convulsions? In these did you lose consciousness? Did you ever have a blow on the head or a fall sufficient to make you unconscious? What other effects were there? Have you had syphilis? Were you treated for this? How long ago did you have it and how long did the treatment continue? Did your hair fall out? Did you have sores on your penis (or vulva) and other parts of the body? Get other details of the effects of the syphilis. Have you had gonorrhea? When? Get details. Have you been affected by the heat? How? Sun-stroke?

Alcohol: Did you take alcohol in any form? How much did you take (number of glasses a day or week)? Have you ever been drunk? Have you ever had delirium tremens? How often? What dates? Have you taken patent medicines? Cologne? For what reason?

Other Drugs: Have you ever taken cocaine or morphine? How long have you taken them? How much have you taken in a day? Have you used headache powders? What were they? How often were they taken and how much? Have you been using sleeping powders or medicine? What were they called? When did you begin to take them? How much did you take before you came here? Why were they taken?

Insight Into the Condition—Emotional: Do you feel all right? or depressed? or excited? or indifferent? Are you always this way? If not, how are you at other times? How were you six months ago? When did this feeling begin? What was the cause of it? Did it come on suddenly? Are you sad or afraid? Have you had any peculiar experiences? Is anything being done to you or has anything been done to you to make you sad or afraid? If not, why are you sad or afraid? What do you fear? Do you think you are being watched? or talked about? Have people been persecuting you? or have they tried to poison you? or to rob you? or to influence your mind? or to compell you to do things that you do not wish to do? Who are trying to do these things? Why do they do it? How have your companions and your friends treated you? Has your wife (or husband) treated you well? Has this been planned out? What makes you think so? (Get a full account of the systematization of the delusions and note especially the retrospective interpretations and the falsifications of same.)

Bodily: Is your bodily condition good? Do you feel physically well? (Get a voluntary account of any peculiar bodily feelings of the patient, and if this is not possible question him carefully, using as few leading questions as possible, to bring out any localized or general feeling of bodily change, etc.)

Mentally: Does your head feel all right? How is your mind? (If there is insight into the condition, get a full account from the patient of what he thinks regarding the changed condition.) Do you have peculiar thoughts? Do thoughts to do or say things spring up in your mind? Can you control these, or do they make you do things?

Auditory Hallucinations: Do you hear things? Are they noises? When do you usually hear them? Are they heard oftener when you are alone, or with other people? Where do they come from (the people about you, or the walls and ceilings, or other rooms)? If voices, can you recognize them? Are they plain? Are they real voices, or only thoughts? Do you hold conversations with them? Do you reply to their questions or to what they say? Do you reply aloud? or do you only think the reply? Do they say pleasant things or disagreeable things? Do the voices or noises go on continually? Do they stop when other

people talk with you? or when you talk? or when you listen to other things, for example, music?

Visual Hallucinations: Do you see things? Are they people? or animals? or things? When do you usually see things (in daylight or in the dark, when you are in bed, or when your eyes are open or shut)? Do they move or remain in one place (do they seem to be in special places on the floor, in the corners of the room, do they always seem to be in front of your eyes, can you get rid of them by turning your head)? Do they seem natural (have they the colors you would expect such things to have, are they transparent, so that you can look through them)? Can you get them to disappear? How do you do this?

Memory: Is your memory good? Has it always been as good (or poor) as it is now? Have you difficulty in remembering any special things?

Attention: Can you attend to things as well as you could? If not, why not?

Thinking: Can you think well? Do you understand readily what is said to you? Does it take you some time to think out the answers to questions? Do you understand what you read?

Capability: Can you do things as well as you could? Do you have any difficulty in fixing your mind on things? Have you any difficulty in starting to do things? Do you feel more disinclined to get up in the morning than you used to do? Have you any difficulty in dressing? In eating? In speaking? In walking? Do you feel able to go to work?

Sleep: Do you sleep well? How many hours at night? Do you ever sleep in the day time? Do you feel rested after your sleep?

Dreams: Do you dream? How often do you dream? Do you dream of things that have happened to you recently, or some time ago? of seeing things? or of hearing things? or of things tasted, smelled, touched, etc., of your doing things (walking, flying, falling, etc.)? of imaginary and impossible things? Does the same dream come twice or more? Do they change every time? Are the dreams pleasant or disagreeable? Get the patient to describe as accurately as he can one or more of his dreams, and if he can not remember them at the time, tell him that you will ask him again about them and to try to remember any that occur

until you ask him again; or, have him write an account of his dreams the morning after they occur.

Explanation: Bring up before the patient some of the things mentioned in the history of his case as obtained from his relations or physician, and get him to explain the events, *e. g.,* impulsive or peculiar actions, suicidal or homicidal attempts, hallucinations and delusions, moral laxness, lack of judgment, etc.

CHAPTER XII

METHODS OF DEALING WITH OBSERVATIONAL DATA

Variation is the universal rule in phenomena of both mental and physical orders. The stars do not retain a constant position; a piece of iron exposed to air and moisture undergoes a certain chemical change; an animal is not the same in two successive moments; a man's thoughts are constantly shifting. When we remember the occurrence of variations in the physical world, it becomes clear that any one measurement of a thing may be influenced by conditions of the moment, and therefore, that each measurement may have one or more errors, or may deviate from a second measurement which is taken at a later time. On the other hand, we must remember that the phenomena of a biological nature are less constant than those of a physical nature, and of the biological phenomena the mental processes are by far the most varied.

Since measurements are possible only by the use of our senses, it is evident that one source of error in the measurement of any particular phenomenon or of a series of phenomena, is the individual, and that one of the greatest possible errors is an observational error. It should be our object to obtain a result that represents approximately the condition we are investigating and as far as possible the special sources of error in instruments and method must be excluded, and we must strive to eliminate other observational errors which depend upon the sensations or perceptions of the experimenter. In order that there be no question regarding the occurrence of certain gross errors, it is necessary to repeat observations whenever possible, to examine carefully all measurements and by combining or averaging the results to determine the most probable value.

On the other hand, it may be our object to determine the variability of some particular series of phenomena. For example, we may take appropriate measures to discover the possible variations in the bodily temperature or in the span of memory. In such cases although the problem which we wish to solve is different

from that of measuring one particular phenomenon, the methods we utilize are approximately the same. We must make a number of measurements and compare these measurements to see in what particulars they vary from each other.

In a small number of observations of one phenomenon the average, and, in a large number, the median, are the most probable values, *i. e.*, they represent the values which are most nearly like the phenomenon that we measure. These values are obtained as follows: the average is the sum of the individual observations divided by the total number of observations; the median is that observation which is the middle one when the observations are arranged in a series of progressively increasing values. In the treatment of psychological measurements the average is mostly employed since it requires fewer observations than the median and it is found to satisfy all the necessary demands for accuracy. To illustrate, suppose for example, we have given a piece of glass, the thickness of which is to be measured in one place by means of a micrometer caliper. Let us assume that we find the following values in a series of ten observations.

Measurements	Variations
10.02	.014
10.03	.024
10.01	.004
10.00	.006
10.02	.014
10.00	.006
10.00	.006
9.98	.026
9.99	.016
10.01	.004

The average is the sum of the measurements divided by 10, viz., 10.006 mm. It is most probable, therefore, that the true thickness of the glass is approximately that of the average. It will be noticed that each of the determinations differ slightly from each other, and they all differ from the average. Should we say that the thickness of the glass is 10.006 mm. it would indicate only the probable value or the probable thickness and not necessarily the true one. Should this figure be reported as the probable value, one might be justified in asking how probable the result is, or in other words, what the chances are that the true

value is that of the average or is near the average. This question may be answered only by calculating the amount of variation from the average that the individual observations have. Each one of the primary measurements differs from the average, some being greater and some less, and if these variations be grouped together and averaged, we have the result .012, which, in connection with the average, gives us an idea how accurate a measurement has been made. In most work it is not possible to give in full all of the original measurements, but if the average be given, and the average amount of variation be known one may reconstruct or understand how much the individual measurements differ from one another. The variations, or deviations as they are sometimes called, are, therefore, to be calculated, and their averages obtained, since the latter gives the reliability of the average or the approximate amount of deviation of the individual observations from the average.

So far, we have considered only the variations in the measurements of a quantity which is fairly constant. When we measure other phenomena, other elements may enter and individual variations may be determined for them. We may take as an example the measurement of the ability to reproduce by movement a certain length of line. A line of 100 mm. drawn on the sheet of paper is placed at a convenient distance from the subject and he is instructed to reproduce the line as accurately as possible. After having drawn the line ten times each one is measured, recorded, and the average is calculated. As in the case with the measurement of the glass, we find that the lines differ slightly

	Measurements	Variations	Errors
	102.0	1.0	2.0
	100.5	0.5	0.5
	102.0	1.0	2.0
	101.0	0.0	1.0
	98.0	3.0	2.0
	104.5	3.5	4.5
	102.0	1.0	2.0
	99.0	2.0	1.0
	101.0	0.0	1.0
	100.0	1.0	0.0
Aver.	101.0	1.3	1.6

from one another. They also differ slightly from the average. We have then in this case the average length of the reproduced

line 101 mm. and an average variation of 1.3 mm. In addition we find that each of the measurements, *i. e.*, each of the lines which were drawn, differs from the line which was presented, and which was supposed to be reproduced. Since we know the length of the line which was to be reproduced and since we know the length of the individual reproductions, the variations of the reproductions from the original may be called errors. These errors may now be determined as is shown in the third column. After these have been calculated and the average obtained we find there is an average error of 1.6 mm. More than this, the reproductions are sometimes larger and sometimes smaller than the original. If the corresponding errors are given their appropriate signs, plus or minus, the algebraic sum taken and the average made, we find the so-called constant error. In this case and in all similar cases, the constant error is the average minus the magnitude, which figure always retains its proper algebraic sign, plus or minus.

We may say, therefore, that in drawing a line of 100 mm. the subject tends to get the reproductions too large (there is a plus

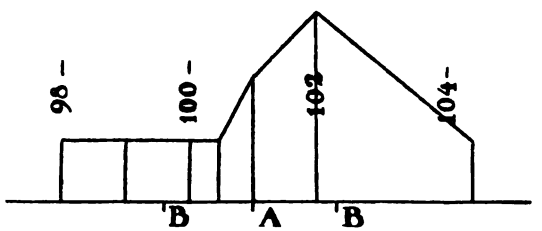

FIG. 30. Distribution of observations in experiment on the ability to reproduce a given length of line. A, average; A–B, average variation.

constant error) and that the average differs only by 1 per cent. from the original, but that the variation in the performance is 1.3 per cent.

These results may be represented graphically as shown in Fig. 30. If the number of observations be large the curve of the distribution of the observations becomes smoother and has the form shown in Fig. 31. This is known as the probability curve. On these curves the average and the average variations are shown, and it may be stated that the latter (in a large series of measurements) represents an area of the curve within which one half of

the measurements falls. The average and the average variations give, therefore, information of the probable value and of the limits within which one half of the observations falls.

The average is used for the determination of other measure-

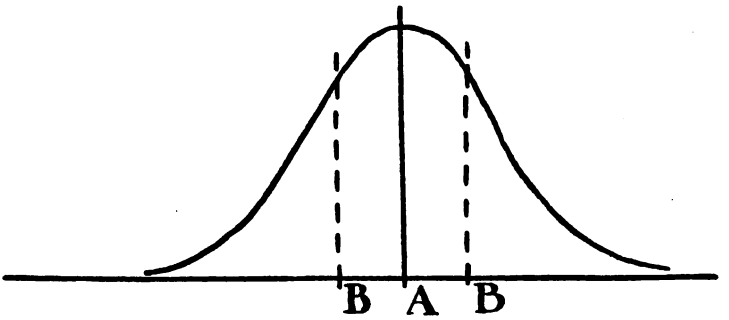

FIG. 31. Probability curve of distribution of observations, when these are numerous. *A*, representing average; *A-B*, representing the average variation.

ments, besides those which are noted above. For example, in the testing the threshold of pressure for touch or for pain on one particular point we may find the following results.

	Measurements	Variations
	24	6
	19	1
	23	5
	14	4
	13	5
	22	4
	18	0
	16	2
	17	1
	14	4
Average	18.0	3.2

Here we see we have the individual measures which differ from each other but which can not be said to differ from an absolute quantity which is to be measured. All that we can do with measurements of this character is to average them and to determine the average variations such as was done in the case in the measurement of the thickness of the plate of glass. The average variation or deviation of the results gives us the constancy of the

threshold value, and in mental tests in which this does not exceed 10 per cent., the average value is considered quite accurate.

In the measurement of the accuracy of other tests, it is not always necessary, and sometimes it is impossible to determine an average. In the experiment of making dots on cross section paper (see expt. *b*, p. 46) it is only necessary to count the number of times the subject hits outside of the squares, and these are to be counted as mistakes. The measurement of the accuracy in an experiment like this is given, therefore, in terms of percentages, the percentage representing the number of times the squares are correctly hit.

Other kinds of tests require still other methods of calculation. Tests of memory, for example, differ very much from the tests which have just been considered. If we test memory by asking the subject to reproduce a series of digits which have been read to him, we find at times all of the digits are given correctly, and in their proper order, but at other times there will be mistakes both in order and in digits. These two errors are illustrated in the example which is here given. It will be noted that in the

Tests	Memory Reproductions	Errors
4—6—2—8—9—5.	4—6—8—2—9—5.	1
7—1—6—5—8—4.	7—1—6—9—8—4.	1
3—9—7—4—6—1.	3—9—7—4—6—1.	
8—2—5—3—1—9.	8—5—2—3—7—9.	2
5—8—9—2—7—6.	5—8—9—2—7—6.	

first reproduction the only error which is made is one of transposition of two digits. In the second test there is a wrong digit given, viz., 9 instead of 5; and in the fourth test there are two digits which are transposed, and one which is wrong.

The calculation of a test like this is comparatively simple if we determine beforehand the criteria of error. It is obvious that a transposition is an error and in a test like the first since there are two transpositions there are necessarily two errors. Actual mistakes, the giving of wrong numerals, are also errors. There are, therefore, two errors in the first test, one in the second test and 3 errors in the fourth test. Although the transpositions are errors just as much as the actual mistakes are errors, the kind of error differs in the two cases, and it would seem wise not to count these two kinds of errors in the same way and of equal

value. In scientific publications these two classes of error should be kept separate, but for comparative clinical work this is not necessary. Each transposition should, obviously, not be counted to be as erroneous as an actual mistake, and it is, therefore, advisable to select an arbitrary standard for the determination of the errors in tests of this character. It is suggested that two transpositions be counted to be the equivalent of one mistake. In other words, since where there is one transposition there must be two, two digits which are transposed would count for as much as the giving of a wrong numeral. This, of course, is an arbitrary standard to select, but it is useful for the sake of comparison and for this reason may be utilized in experiments of this character. In the comparison of the total series of experiments, using as the basis of calculation the method which has just been suggested, we see there is a total of 4 errors. The total number of the digits which were to be reproduced is 30 and the accuracy of the subject may be therefore said to be 26 divided by 30 or 87 per cent.

This figure does not, however, give the true accuracy, for even if the subject did not hear the six digits in any series, but did know that six digits were to be given by him the chances are that he would be able to give some of the digits which were determined upon. The chance of his getting the six digits correctly in order are 1 to 9, raised to the 6th power, or one chance in about 60,000, *i. e.*, 1:9 for the first digit, 1:9 for the second digit, etc. The chance of his getting the six digits correctly, even though improperly placed, would be much greater than this. In the 87 per cent. of correctness there is therefore some chance that the individual did not remember but simply guessed at some of the digits which by chance happened to fit into the proper test or even into the proper place in the test. The elaborate calculation of the probability and comparison with the percentage which is attained is both tedious and unnecessary for clinical tests, and it is sufficient to give the per cent. of correct responses as the result of the test.

A similar method is utilized in the calculation of such experiments as that on the double point threshold (see expt. *d*, page 23). It will be found in an experiment of this character that occasionally a single stimulus will be reported to be double, but

more often double stimuli will be reported to be single. It is therefore, better to count the double stimuli than the single, although one may be more accurate by giving the percent of correct replies to both forms of stimuli. See also discussion below.

The correlation of one process with another may also be made by comparing directly measurements of individual processes with measurements of other individual processes. In this way it is found that there is more or less correlation between apparently different mental states and this correlation is commonly conceived to be present in physiological processes in different diseases. The mathematical treatment and methods of determining the correlation will not be discussed here, but those who are interested are referred to the references noted below.

The various methods which have been used in the performance of psychological work are those which have been called average error, right and wrong cases, minimal changes, and estimated amount of difference. The method of average error is similar to that which is given above in connection with the test of the ability to draw a line. The subject is tested by the method of reproduction or tested as in the case of the skin sensations threshold mentioned above. The average is taken of the individual measurements. The method of right and wrong cases is similar to that which is described in connection with the testing of the double point threshold. Here, we deal with percentages of correct or incorrect responses. The method of minimal changes is similar in many respects to that of right and wrong cases and when logically followed out results in exactly the same thing. For details of this the reader is referred to the texts mentioned below. The method of estimated amount of difference has very limited application. This is a method whereby the individual estimates the difference between stimuli, one stimulus is the same magnitude as another, or is twice as great, or half as great. This method corresponds more nearly with that of average error than with the other two methods, but, as has been said, it has a very limited application especially in psychopathological work.

In performing tests which require comparison or judgment of two things, the stimuli may at times be presented simultaneously and at times successively. The experiments described for testing

[illegible] the sense of passive pressure and the sensations of movement by lifted weights are examples of the first, which require successive stimuli. That the subject may not be influenced by a knowledge of the relations of the successive stimuli in these and in similar tests, the weights should be presented in an irregular order and the subject is required to judge whether the first or the second is the heavier. It is found that in a series of tests some experimenters tend to stimulate the subject alternately with the heavy and light weights and with light and heavy. This order is soon unconsciously appreciated by the subject and the appreciation influences all the tests. For this reason I use the following formulæ which are selected by chance, i. e., by placing 5 of each word "light" and "heavy" in a hat and drawing one out at a time:

L	H	L	H	L	L	H	L	H	H
L	L	H	H	L	H	L	H	L	H
L	H	H	L	L	H	L	H	H	L
L	H	H	L	L	H	L	L	H	H
L	L	H	H	L	H	L	H	L	H
L	H	H	L	L	H	L	L	H	H
H	L	L	L	H	H	L	H	H	L
H	L	H	L	L	H	L	L	H	H

"Usually two of these formulæ [20 tests] are sufficient for the determination of the discrimination ability of the subject with the stimuli selected, and often it is found that one (i. e., 10 tests) will give results that indicate the general ability of the subject. The accuracy of judgment is to be represented in terms of percentage.

The same formulæ may be used for the tests of other kinds, comparison of the length of lines, of the double point threshold, etc., and the letters may be altered for these purposes. For the double point threshold, for example, the formulæ would read:

[1] This means that, in the test of passive pressure sense, for example, the heavy weight is placed on the hand for one half second and replaced by the lighter weight and the subject then makes a judgment. The second test is made with the same order, and in the third test the lighter weight is first placed on the hand and the heavier weight is the second stimulus, and so on.

2—2—1—2—1—1—2—1—2—1
2—1—2—2—1—2—1—2—1—1
1—2—2—1—1—2—1—2—2—1
etc. etc. etc.

It should be remembered that in the double point threshold test each test consists not of two stimuli but of a single stimulation either with one point or with two points. The manner of performing the tests is, therefore, different from that with weights and the digits of the formulæ do not mean that the two points are to be applied first and then the one point. In tests of this character, according to the first formulæ, after two points have been applied to the skin a judgment is required of the character of the stimulus, and after this has been given a second stimulus of the same kind is given, followed in the third test by a single stimulus, etc. In the calculation of the results of tests of this character it is important that the percentage of correct responses be given for the single and for the double stimuli, and for this reason the number of tests is usually 20 or more, *i. e.*, according to two or more of the formulæ.

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See also references 11, 12, 17 and 19 (Chap. I).

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